POWER

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Thoroughness

A YOUNG man was turning a nut onto a bolt. It was not an easy fit and the engine room was in a hot, close basement.

He stuck a pipe onto the handle of the wrench, braced his foot against the bed of the machine and got the nut practically seated when, suddenly, the resistance eased off.

He knew that he had cracked the stud, but there was enough left to it to hold the nut in place against a light tap of the wrench. To unmake the joint, back the stud out, make or get another meant more hours in that sweat box and a bawling out. It was nearly lunch hour.

He put on the remaining nuts and left it with the cracked stud.

This was characteristic of the man. His only interest in a job was to get it over. If it would pass for the time being, that was enough.

If the thing went wrong later, it might cause a lot more trouble and expense and delay to fix it than it would have taken to do it over thoroughly at the time, but somebody else would have the trouble and pay the bill.

As he sat with his buddy at lunch, the conversation turned, as quite usually, upon the boss.

He had found favor with the proprietor and had been promoted over their heads.

What kind of a show did a feller stand when a bloke could shove in like that and cop off all the easy and good paying jobs and the men that were there before were left to do the real work and all he had to do was to tell them what to go at next?

A feller ain't got a chance in this game without he's got a pull.

And neither of them appreciated his hopeless incapacity for a position of real responsibility or knew that the proprietor had their number and knew their limitations and had picked the other as superintendent because he knew how to get things done as they should be and so that they would stay done when they were finished.

F. R. Low

University of Rochester Installs New Heating Plant

Relocation of Buildings on New Campus Necessitates the Construction of a Modern Heating Plant—Water-Tube Boilers Supply High-Pressure Steam to Buildings—Complete Set of Measuring Instruments Installed—Plant Used as Testing Laboratory by Engineering Students

By J. W. GAVETT, JR.
Professor of Mechanical Engineering

THE University of Rochester has recently completed the construction of its new School of Medicine and Dentistry and the Strong Memorial Hospital on the outskirts of Rochester, several miles from the old campus, which is in the heart of the city. Funds have recently been acquired to construct and endow new buildings for the College of Arts and Science, on a site adjoining the Medical School, the plan being to leave the old campus to the College for Women. These plans were all projected when the new heating plant was designed and had considerable influence on its layout.

The boilers consist of two units of 4,000 sq.ft. each and one of 2,000. All are built for 200 lb. working pressure, so that turbo-generators can be installed later if desired. At present steam is generated at 100 lb. gage for heating and electrical energy is purchased.

Building of Ample Size

The building, which is of steel and brick construction, is large enough to house another 7,000 sq.ft. of boilers to take care of the arts buildings when erected. It so happened that it was possible to erect the boiler house midway between the Medical School and the proposed college site, and at the same time place it close to two railroads and on a paved thoroughfare. This gives a central distribution point and permits carload delivery of coal, as well as easy access for trucks.

The floor area is 95x55 ft. and the height 63 ft. The basement floor is 15 ft. below the firing-floor level, thus giving about 14 ft. clear headroom. This permitted placing most of the piping on the basement ceiling, leaving the firing floor clear of obstructions.

Coal is dumped directly from cars into a conveyor or into a 1,000-ton storage bin, as may be desired. The conveyor carries the coal to the bunker over the firing floor, and a crusher is provided for use if necessary. A weighing larry feeds the stoker hoppers.

It is planned for the near future to distribute coal from this plant to the other two plants operated by the university. For this purpose a telescoping chute, shown in the background of Fig. 2, has been provided to carry coal from the overhead bunker through the north wall of the building into motor trucks. Careful estimates indicate this plan will effect a considerable saving, and it has the further advantage of giving all three plants exactly the same fuel, thus eliminating one variable in comparing operating efficiencies. An automatic sampler will be installed, since the university buys coal on specification and frequent samples must be taken.

Two mains, 10 in. and 6 in. in diameter, respectively, carry the steam at boiler pressure to the main valve room in the basement of the school, through a waterproofed reinforced-concrete tunnel, 6x7 ft. inside and about 700 ft. long. This is shown in Fig. 1 and its course is indicated by the white line between the plant and the buildings in Fig. 4. In the basement the pressure is reduced to 1 lb., or less for heating, and to 25 lb. for water heaters, laundry, sterilizers, etc. The two mains are, of course, cross-connected so that the demand may be supplied from either one or both. High pressure is carried directly through the basement to two of the farther buildings, the Nurses Dormitory and the new Municipal Hospital, to the latter of which the university sells heat.

Low-pressure returns are taken back to the boiler-house basement through an 8-in. main, then lifted by the vacuum pumps to an air-separating tank 30 ft. above the firing floor, from which they flow by gravity to the open heater. The latter is on a platform about 15 ft. above the floor. High-pressure returns are handled by a separate line and are fed directly to the heater by a small pump.

Three feed pumps are installed—a large reciprocating unit and a turbine-driven centrifugal, each capable of handling the ultimate capacity of the plant, and a small reciprocating unit for summer loads.

Modern Pipe Joints

All pipe joints in the tunnel are oxyacetylene-welded. Loops are provided at either end, and two expansion joints are placed at equal intervals along the length of the tunnel.

The plant is equipped with underfeed single-retort stokers, forced draft being supplied by an engine-driven fan in the basement. Air for the fan may be taken from outdoors or from the boiler room as desired. In addition, there are a motor-driven fan of large capacity, and a small turbine-driven high-speed blower for use with the small boiler alone.

Regulation is of the balanced-draft type and is almost entirely automatic. The system has been very satisfactory except on days of high wind, when it is somewhat too sensitive.

It has been the practice so far to carry the load on one of the large units up to about 150 per cent of rating. Above this the small boiler is cut in to carry the excess.

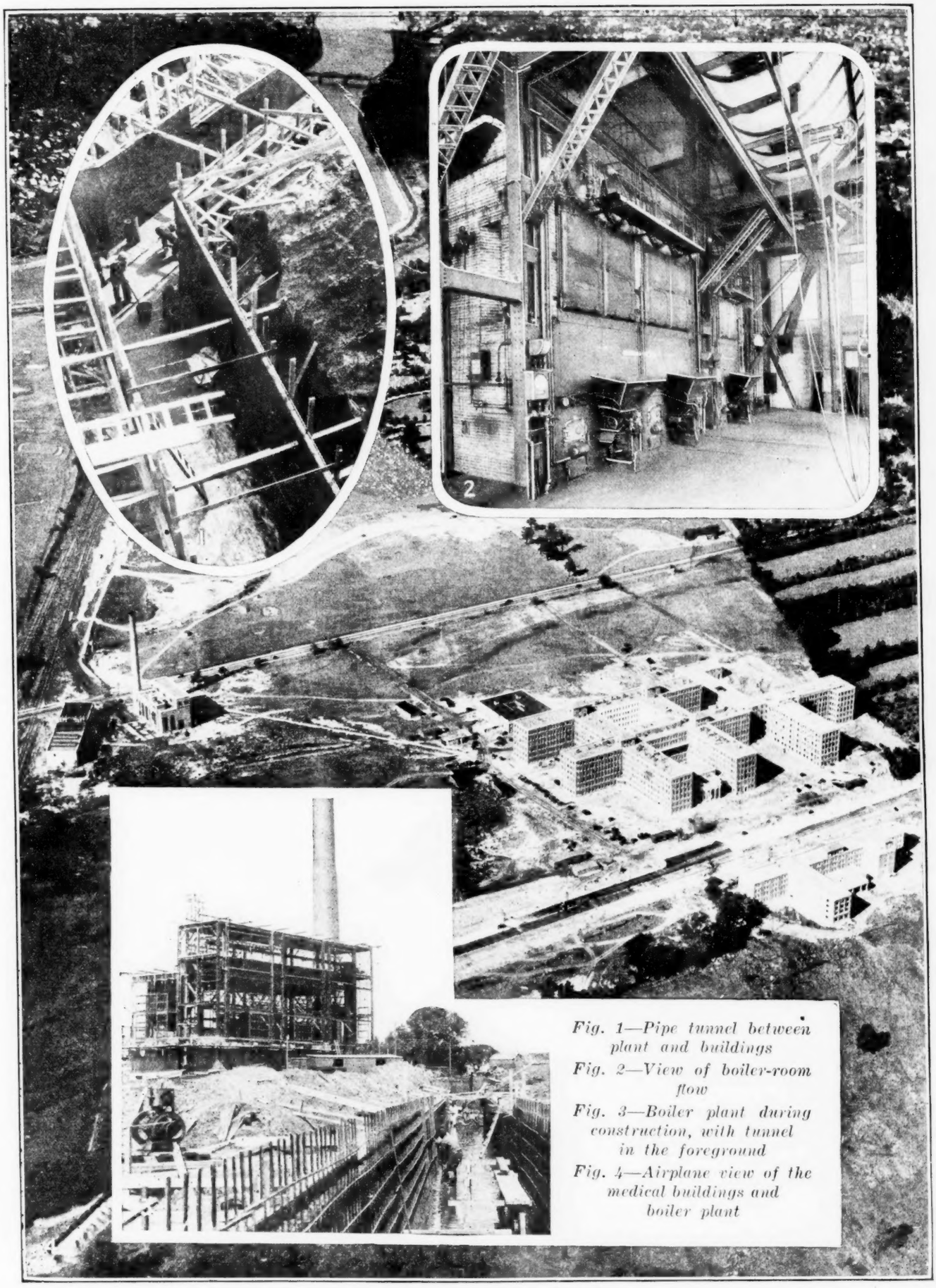


Fig. 1—Pipe tunnel between plant and buildings

Fig. 2—View of boiler-room floor

Fig. 3—Boiler plant during construction, with tunnel in the foreground

Fig. 4—Airplane view of the medical buildings and boiler plant

This has been necessary for a few hours only on the coldest days, with outdoor temperatures of 15 deg. or less. With the available fuel this scheme has been found to give the best average results. The crew of the plant is unusually interested and willing to experiment to find the most economical method of operation.

Devices are installed for measuring the following items: Weight of coal; weight of feed water; weight of steam from each boiler; flue temperature; temperature of water to heater; temperature of water to boilers; temperature of outdoor air; draft in furnace; draft in uptake; pressure in wind-box.

Readings of most of the instruments are taken every hour, water, coal- and steam-meter readings being in-

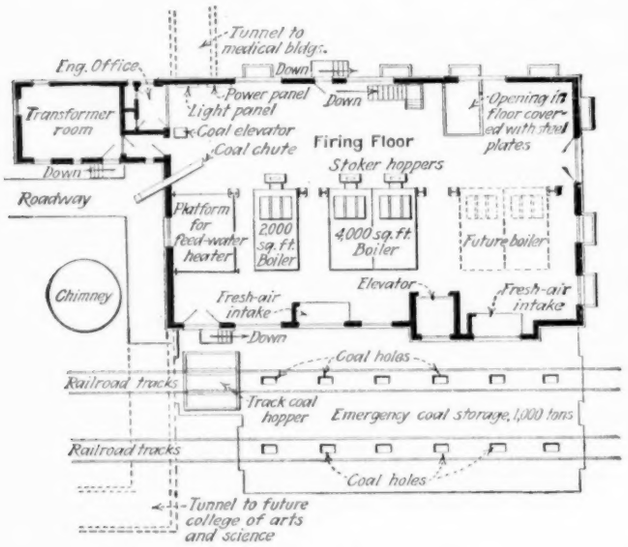


Fig. 5—Floor plan of the boiler house

serted at the end of each eight-hour shift. Averages and totals are taken from this sheet for filling in a small card, which is forwarded to the Department of Mechanical Engineering, where monthly summaries are made and average monthly efficiency computed. Copies of the monthly summaries are sent to the treasurer of the University and to the chief engineers of the respective plants.

Incidentally, the evaporation per pound of coal for each shift is chalked up on a blackboard in the boiler room. These figures, of course, cover too short a period of time to be very accurate, but they form the basis for enthusiastic rivalry between shifts, which has done much to increase the efficiency of operation.

Plant May Be Used as Students' Testing Laboratory

The plant has been so designed that it may be used as a laboratory for the engineering students of the university. Many experiments, such as boiler testing, meter calibration, economy tests on steam pumps and engines, etc., can be run under actual operating conditions rather than in the artificial perfection of the usual college laboratory. Plugged tees are placed in the suction and discharge lines of the water end of each pump and in the exhaust pipe of each steam-driven auxiliary. It is evident that with this provision any alterations in piping incident to testing can be made without interrupting the operation of the plant, and with a minimum of expense. In addition, steam sampling tubes have been inserted in the outlets of the boilers and in the steam pipes feeding the auxiliaries, thus permitting the determination of quality wherever necessary for heat-balance computations.

This plan might well be followed more generally by power-plant designers. Very few small or medium-sized industrial plants can be arranged for testing without difficult and expensive piping changes and possible interruption of operation. On the other hand, the expense of providing for such changes during the construction of a plant is negligible.

The plant was designed by Allen S. Crocker, consulting engineer, associated with Gordon & Kaelber, architects for the Medical School and Hospital group of buildings.

PRINCIPAL EQUIPMENT OF UNIVERSITY OF ROCHESTER HEATING PLANT

Boilers, type	Horizontal water-tube
size (sq.ft. surface)	Two 4,000 and one 2,000
make	Babcock & Wilcox Co.
Stokers, type	Underfeed single-retort
make	Combustion Engineering Corp.
Draft fans, make	B. F. Sturtevant Co.
type	1 steam-driven, 1 motor-driven and 1 turbine-driven
Draft regulation	The Engineer Co.
Heater, type	V-notch open
make	The Cochrane Corp.
Feed pumps, type	2-duplex steam and 1 turbo-centrifugal
make	Worthington Pump & Machinery Corp.
Coal and ash handling equipment	Brown Hoisting Machine Co.
Ash hoppers	Allen-Sherman-Hoff Co.
Chimney	Radial brick, 192 ft. high
Chimney builder	Wm. Summerhay's Sons, Inc.
Soot blowers	Diamond Power Specialty Co.
Boiler meters	Bailey Meter Co.
Draft gages	Bailey Meter Co.

A Test of Dished Heads

In view of the fact that the stresses in dished heads have long been the subject of controversy, designers and inspectors of boilers and other pressure vessels will be interested in the results of tests made by the Union Carbide Corporation and reported by S. W. Miller in the August issue of *Mechanical Engineering*.

Details cannot be given here, but it may be noted that the tank tested had an internal diameter of 60 in., heads dished to 60 in. radius with knuckles of 6 in. inside radius and straight sections of 6 in. The shells and heads were 1¼ in. thick except that the manhole head was 1½ in. thick. The heads were welded to the drum. Designed for a working pressure of 337 lb., corresponding to a fiber stress of 9,000 lb., the tank was tested to triple this pressure and stress.

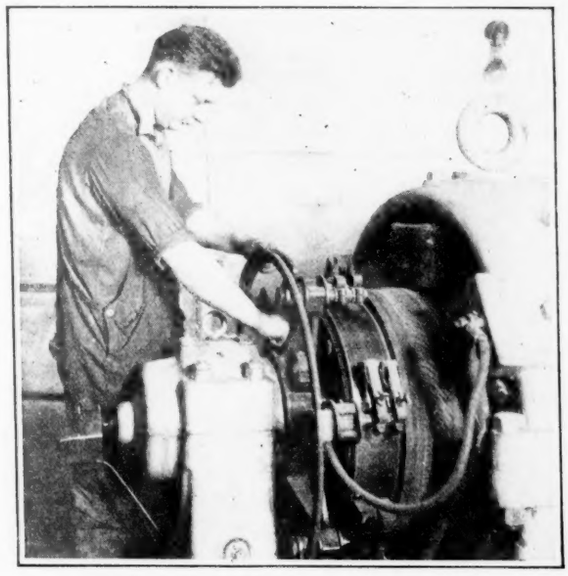
Strain measurements were taken at all important points. No distortion was found in any of the welds, but the heads gave evidence of overstrain near the manhole and at the knuckles. The test was concluded by raising the pressure to 930 lb., at which point the head broke diagonally through the manhole. Mr. Miller draws the conclusion that the A.S.M.E. Code formulas for the radii of knuckles and the dimensions of manhole heads are unreliable and should be the subject of further study.

Water systems have such a comparatively low ground resistance that where they are in proximity to pipe or plate grounds, it has been found that a difference of potential will exist between the two during ground fault conditions on electric circuits, which constitute a hazard to life unless the water system and pipe or plate grounds are connected together.

Locating Faults in Direct-Current Machines

Tells How the Wrong Brush Position Causes Sparking at the Commutator

By C. O. MILLS



ON DIRECT-CURRENT machines the commutator and brushes are accountable for about 90 per cent of all the operating troubles, and practically all the faults that may develop in the machine will produce sparking at the brushes. From this it is evident that sparking at the brushes of a direct-current motor or generator is an indication of trouble. Since the commutator and brushes play such an important part in the satisfactory operation of direct-current machines, it is well to have an understanding of just what their function is and how the positions of the brushes on the commutator affect the performance of the machine.

The current generated in the armature of any machine is naturally alternating. It is the function of the commutator to rectify the alternating current in the armature to a direct current at the brushes. How this is done will be made clear by considering Figs. 1 to 4, which are diagrams of a two-pole ring-armature direct-current generator.

Direction of Current in Armature

In Fig. 1, with the armature rotating in the direction of the curved arrow, the direction of the current in the armature circuits will be as indicated by the arrowheads. That the current in the armature is alternating is evident by its direction in the two halves of the winding. In the half above the brushes the direction of the current on the outside of the armature is away from the reader and in the half of the winding under the *N* pole it is up through the plane of the paper. When the armature has made one-half revolution the current in the two halves of the winding will have reversed, since the flow of the current in the winding under the poles must have the same direction as now. Therefore, for each one-half revolution of the armature the current changes its direction in the winding, and if the winding were connected to an external circuit through brushes on continuous rings, an alternating current would be supplied. When the brushes rest on a commutator, the current is reversed in one coil at a time, as the commutator segment to which the coil connects passes a brush.

In Fig. 1 the direction of current in coil *A* is down through the paper. When the armature has revolved to where the brush rests on segments *a* and *b*, Fig. 2, coil *A* is short-circuited by the brush. The current can now pass from the — brush through coil *C* into the top half of the winding and through coil *B* into the bottom half of the winding, without going through coil *A*. Further movement of the armature brings the — brush on segment *a*. When this happens, the current must build up to full value through coil *A*. The current is now in the opposite direction in coil *A*, Fig. 3, from what it was when the coil was in the position Fig. 1. In other words, in the time that it takes a segment to pass a brush the current must reverse in the coil connected to this segment.

If it is assumed that the commutator has only 24 segments as in the figures and the armature runs 1,000 r.p.m., then $24 \times 1{,}000 = 24{,}000$ segments pass each brush per minute, or $24{,}000 \div 60 = 400$ per second. If it takes coil *A* only $\frac{1}{800}$ part of a second to move from the position Fig. 1 to the position Fig. 3, then the current in the coil must decrease from full value to zero and build up to full value in the opposite direction in this short time. This is equivalent to reversing the current in the coil 400 times per second and makes it evident that if trouble is to be avoided, conditions must be correct at the commutator.

Effects of Inductance

Whenever the value of a current is changed in a circuit, due to inductance, a voltage is generated in the circuit that opposes the change. With the brush in contact with segment *a* the easiest path for the current is from the brush to segment *a*, to coil *C* and to the right through the winding. If it were not for the inductance of coil *A*, this is what would happen. But when the current starts to die down in coil *A*, a voltage is generated in this coil which tends to keep the current flowing and, unless other influences are brought into play, the current will not decrease as quickly as it should.

As the brush moves off segment *b*, the brush surface in contact with this segment becomes smaller, consequently the resistance of the path for the current to coil *A* through segment *b* increases and helps to reduce the current. This is one of the reasons why a carbon or a graphite brush is less likely to spark than a copper

brush; it has a higher resistance and tends to cause a quicker change of the current in the coil under commutation.

When the current is brought to zero in the coil under commutation, it must be built up to full value in the opposite direction. As the current increases in value, a voltage is induced in the circuit that opposes the increase. From this it is seen that under normal conditions things are not very favorable for reversing the current quickly.

Unless the current is completely reversed in coil *A* when the edge of the brush leaves segment *b*, the current will be broken and an arc will occur, much the same as when a switch is opened on a live circuit. The severity of the arc will depend upon the intensity of the current broken. This is one of the conditions that causes sparking at the brushes. If conditions are too unfavorable for the reversal of the current in coil *A*, the current will be maintained in it to such a high value as to heat the edge of the brush to a temperature where it will glow before it breaks contact with segment *b*. This is one of the things that causes what is known as glowing of the brushes.

One of the ways of assisting the reversal of the current in the coil *A* would be to produce in it a voltage that is in opposition to the direction of the current in the coil, indicated in Fig. 1. The direction of the voltage generated in the coils under the *N* pole is in opposition to the direction of the current in coil *A*, Fig. 1. By shifting the brushes to some such position as in Fig. 4, the coil under commutation will be in a field that will generate a voltage in it that opposes the normal direction of the current in the coil.

The direction of the arrowhead on coil *D*, Fig. 4, indicates the direction of the voltage generated in this coil when under commutation. Comparing this with the direction of the current of coil *A*, Fig. 2, it is found that the voltage in coil *D*, Fig. 4, is opposite to the

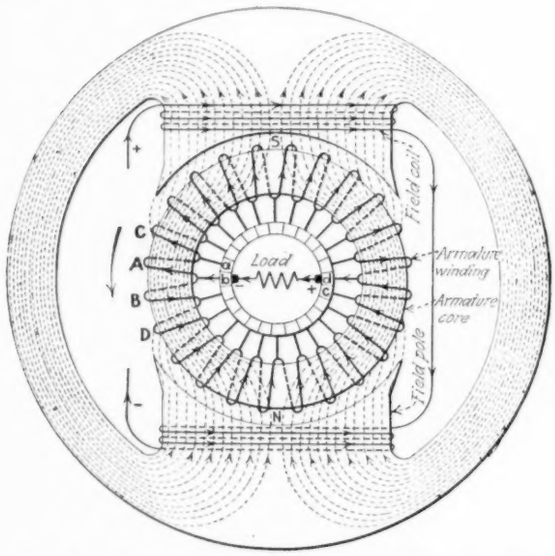


Fig. 1—Diagram of shunt-wound direct-current generator

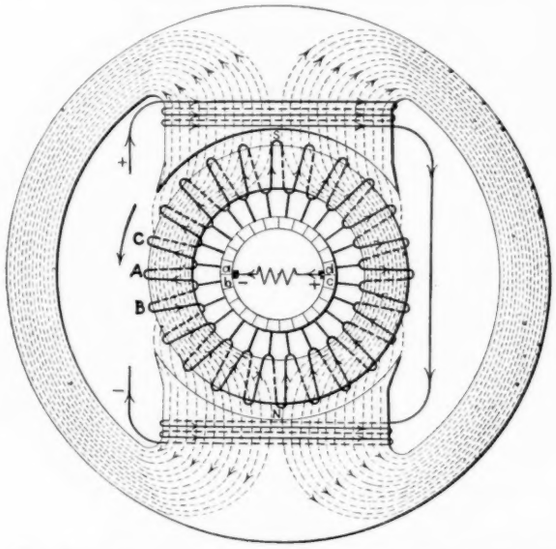


Fig. 2—Same as Fig. 1, except the armature has been revolved one-half segment

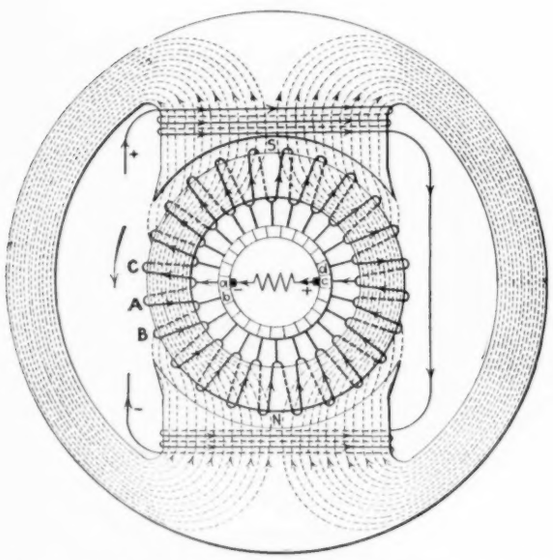


Fig. 3—Same as Fig. 1, except the armature has been revolved one segment

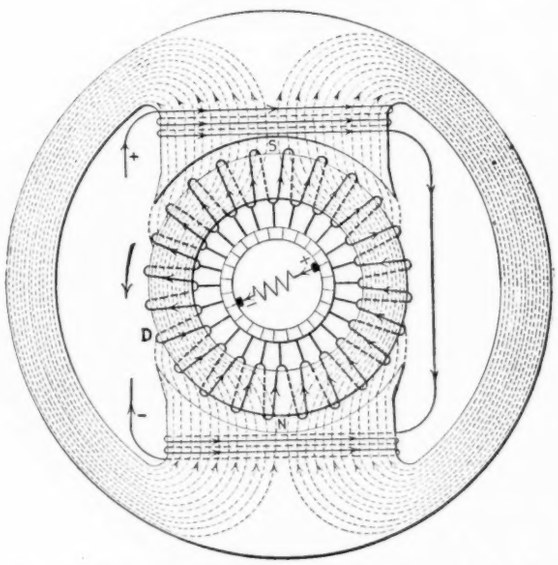


Fig. 4—Same as Fig. 1, except the brushes have been shifted in the direction of rotation

current in coil *A*. Therefore when coil *D* is short-circuited by the brush, it will have a voltage generated in it to assist in reversing the current. When the brushes are moved in the direction of rotation on a non-interpole generator to improve commutation, the same thing is done as shown in Fig. 4. In practice the brushes are moved to a position where the coil under commutation will have a voltage generated in it that will reverse the current in the coil while the brush is passing from one segment to another.

One of the difficulties in shifting the brushes to get good commutation, is the effect of armature reaction. For example, in Fig. 1 the direction of the current in the armature winding is such as to produce an *N* pole between coils *A* and *B* and an *S* pole on the opposite

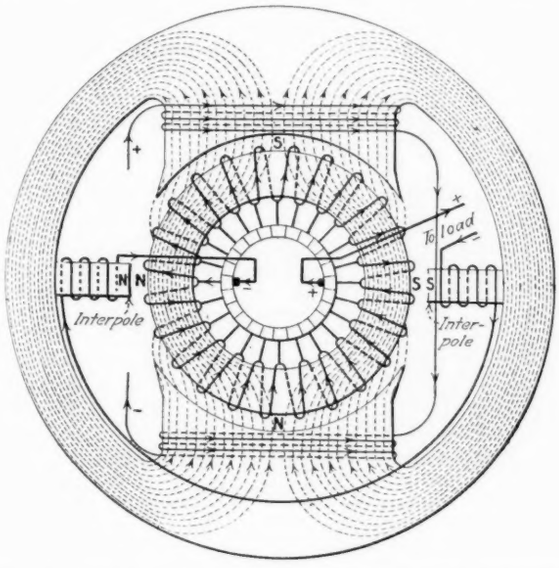


Fig. 5—Diagram of shunt-wound interpole generator

side of the armature. The *N* pole of the armature opposes the *N* main pole and will tend to push the main pole's field to the right.

The strength of the armature poles varies with the current in the winding. At no load the armature poles are of zero strength, and at full load they have a maximum strength. Then at no load the armature poles have no effect on the main poles and at full load will have a maximum effect. This action causes the neutral position of the armature to shift. At no load the brush position would be on the neutral in Fig. 1, whereas at full load, due to the armature poles' shifting the field of the main poles, the neutral is in some such position as indicated by the brushes in Fig. 4.

A position of the brushes that will give good commutation at one load may cause sparking at another load, on account of the neutral shifting, as previously mentioned. Another objectionable feature of shifting the brushes to improve commutation is that shifting the brushes off the neutral brings the armature poles in a position where they are more effective in opposing the main poles. For example, the armature poles are midway between the main poles in Fig. 1 and will have the minimum effect. In Fig. 4 shifting the brushes has brought the armature poles under the tips of the main poles, where they will be more effective in distorting the main-pole field.

In the interpole machine a second set of poles are placed between the main poles with a winding on them connected in series with the armature, as in Fig. 5. These poles are made the same polarity as the armature poles, and as the winding on them is in series with the armature, their strength varies as the strength of the armature poles. The number of turns in the interpole winding is made such that the strength of the interpoles will neutralize the armature poles and provide a field of a value that will generate a voltage in the coils under commutation, sufficient to reverse the current in them, in the time they are passing under the brushes. The interpoles do two things—they maintain the neutral in a constant position and help reverse the current in the coil under commutation. From the foregoing it is evident that brush position is an important factor in the satisfactory operation of direct-current machines and should be one of the first things checked in case of trouble.

Capacity of Wrought Pipe

By C. F. Fessler

The majority of dimension tables covering standard wrought pipe give the internal area in square inches, while the engineer usually needs values in terms of square feet. In the table below three classes of pipe are shown with the cross-section areas in square feet. The columns headed "Capacity" give the capacity in gallons of one linear foot of pipe. The "Areas" and "Capacities" for extra-heavy and double extra-heavy pipe were calculated for this article and are here published the author believes for the first time.

If Q equals the discharge in cubic feet per minute through a pipe of given size, then $Q \div$ area equals velocity in feet per minute. If *Q* equals the discharge in gallons per minute through a pipe of given size, then $Q \div$ capacity equals velocity in feet per minute. Therefore, if either the discharge or the velocity are shown, the unknown may be determined by one calculation.

Example: Assume *Q* equals 400 cu.ft. per min. flowing through a 10-in. standard-weight pipe, what is the velocity in feet per minute and in feet per second?

Referring to the table, we find the area for a 10-in. pipe is 0.547 sq.ft. Dividing the cubic feet per minute by the area gives the velocity per minute, or $400 \div 0.547 = 731$ ft. per minute, or 12.18 per second.

If the computations are performed on a slide rule having an inverted scale (such as scale *CI* on a Manheim Polyphase slide rule), velocity *V* can be read in either feet per minute or feet per second with only one setting of the slide.

AREAS AND CAPACITIES OF STANDARD PIPES

Nominal Pipe Size, In.	Standard Weight — Internal Area, Sq.Ft.	Standard Weight — Capacity, Gal. per Lineal Foot	Extra Heavy — Internal Area, Sq.Ft.	Extra Heavy — Capacity, Gal. per Lineal Foot	Double Extra Havy — Internal Area, Sq.Ft.	Double Extra Havy — Capacity, Gal. per Lineal Foot
¼	0.000722	0.00541	0.000472	0.00353	.....	.....
⅜	0.00211	0.0158	0.00160	0.0120	0.000326	0.00244
½	0.00370	0.0277	0.00314	0.0235	0.000965	0.00722
1	0.00598	0.0447	0.00493	0.0369	0.00188	0.0141
1¼	0.0141	0.106	0.0122	0.0909	0.00646	0.0483
2	0.0233	0.174	0.0204	0.153	0.0121	0.0904
2½	0.0332	0.248	0.0292	0.219	0.0168	0.126
3	0.0512	0.384	0.0456	0.341	0.0285	0.213
3½	0.0687	0.514	0.0615	0.460	0.0402	0.301
4	0.0885	0.661	0.0795	0.595	0.0536	0.401
5	0.139	1.04	0.126	0.945	0.0908	0.674
6	0.201	1.50	0.180	1.35	0.130	0.970
7	0.269	2.01	0.239	1.79	0.188	1.41
8	0.347	2.61	0.317	2.37	0.258	1.93
9	0.436	3.26	0.406	3.04	.....	.....
10	0.547	4.09	0.519	3.88	.....	.....
12	0.786	5.88	0.753	5.63	.....	.....
14 O. D.	0.956	7.16	0.921	6.89	.....	.....
16 O. D.	1.27	9.49	1.23	9.17	.....	.....
18 O. D.	1.67	12.45	.....	.....	.....	.....
20 O. D.	2.02	15.12	.....	.....	.....	.....

How the Bailey Meter Control Operates

IN THE control of combustion in a boiler furnace, whether manually or automatically, there are two items of importance—output and efficiency. The maintaining of output is of primary importance, but this is a relatively easy task consisting of maintaining the steam pressure. The control of combustion efficiency, on the other hand, is a somewhat more complicated problem, and in studying this problem in general, it is convenient to consider the function of any combustion control in terms of the reduction of losses. The unavoidable losses in a boiler furnace may be classified under three heads—combustible in refuse, unburned combustible constituents in the flue gas, and the sensible heat of excess air together with the accompanying water vapor.

WHILE this type of boiler control has been in service for some time, its method of operation is not widely known, and *Power* is glad to present this simple explanation of the device.

The loss due to unburned combustible in the refuse is a matter of stoker and furnace design. The loss due to unburned volatile combustible gases passing out through the stack is a matter of proper mixing and furnace design. It is true that operating conditions influence these losses, but so far as automatic control is concerned, any such influence is incidental.

The losses that it is the function of any system of combustion control to reduce are those due to excess air entering the furnace through the fuel bed and to unburned gas escaping up the stack. No system of combustion control can eliminate the loss due to air entering through leaks in the setting. That is a function of maintenance of the setting in airtight condition. Any system of combustion control, whether mechanical or manual, so far as economy is concerned, directs itself exclusively to reducing the excess air to the lowest practicable limit without permitting losses due to CO and other combustible gases.

An automatic combustion-control system is simply a mechanical device to do something that an intelligent operator would do by hand. Now what does a good operator do in controlling combustion manually? In the first place, he watches the steam pressure, and if this falls or rises he correspondingly increases or decreases the rate of heat generation within the furnace. Thus he maintains the boiler output. He then watches some instrument that indicates the quantity of excess air being supplied or the relation between the air supply and the fuel supply. This instrument may be a CO_2 machine or a steam-flow air-flow meter.

An operator will watch the instruments, and in accordance with their indications control the speed of motors, the opening of dampers, and other equipment that affects the supply of heat to the boiler and the ratio of air to fuel. He controls the speed of motors by operating ordinary throttle valves or electrical controllers. He controls the opening of a damper by means of a chain or gearing, or perhaps by controlling a small motor driving the damper. Thus does he maintain the boiler efficiency.

What sort of mechanism can replace this operator? Any automatic control scheme of this sort must be made up of three distinct elements: (1) An element that is sensitive to the quantity whose variations dictate the change. (2) A transforming element whereby any departure of the quantity measured, as indicated by the sensitive element of item (1), is transformed into some motive power whereby control can be accomplished. This is usually either the mechanical motion of a piston or diaphragm, or floating bell, or an electric current established through the closing of an appropriate switch. (3) A second transforming device whereby the motive power established in item (2) is applied to the operation of a motor controller, a turbine throttle valve, a damper or a variable-speed drive.

The Bailey meter control system utilizes electrical motive power; that is, the element that is sensitive to the critical condition actuates a transforming device whereby the rate of variations in the controlled quantities is duplicated by electric currents set up through the definitely timed operation of appropriate switches, and these in turn actuate a second transforming device comprising clutches to apply the power of a motor to the operation of controllers, dampers and the like.

The Bailey control is in two distinct parts, one to maintain output, the other, efficiency. Hence there are two distinct sets of controlling elements in the system.

The first of these responds to steam pressure and has under its control two switches, one to increase, the other to decrease, the rate of heat generation. When the steam pressure is normal, both switches are open. When the steam pressure is high, the "less" switch is closed. When the steam pressure is low, the "more" switch is closed. Each of these switches actuates a clutch that rotates in one direction or the other a shaft operating a controller for varying the speed of motors driving the fuel-feeding mechanism and the draft fans or dampers.

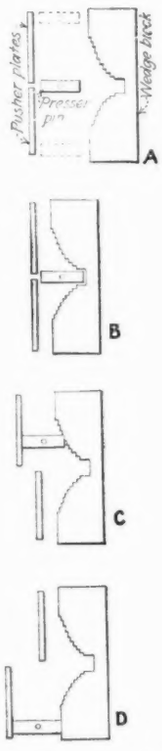


Fig. 1—Wedge block mechanism

An entirely independent sensitive element responds to the ratio of steam flow to air flow. When this ratio is correct, nothing happens. When the air is excessive, a switch is closed and the mechanism reduces the supply of air. Similarly, when the air is insufficient, its supply is increased.

In the case of stokers the fuel supply rate may be permitted to vary more or less, but in the case of pulverized coal it is necessary to maintain continuous adjustment. Moreover, inasmuch as operation is effected with a minimum of excess air, it is necessary, in the case of pulverized coal, to be careful during the period of change. Pulverized coal is not usually fed with perfect regularity, and a slight excess of air should be supplied normally to take care of such irregularities. During periods of change these irregularities in feeding are likely to be more pronounced, and therefore it is desirable during any change to maintain a somewhat higher excess of air than is required during normal steady operation. Hence this control can be so arranged that when the rate of heat supply is being increased, the air supply increases more rapidly than the coal supply. When the rate is being decreased, on the other hand, the air supply decreases more slowly than the coal supply. Both of these differences may be effected through appropriate differences in speed ratio of the gears that drive the controllers for air and coal feed.

The Mechanism Used

The accomplishment of all these adjustments is through the medium of an apparatus which at first glance appears complicated. As a matter of fact, however, the complication is similar to that of a typewriter, in which a relatively simple mechanism is repeated some forty odd times, with the result that the assemblage seems at first to be an extremely complicated machine. If one analyzes it into separate parts, however, he realizes at once that this appearance of complication and delicacy is illusory.

In a similar way the Bailey meter-control system involves easily understandable simple elements which are repeated for performing the desired functions, and the result seems more elaborate than it really is. As a matter of fact, the elements that go to make up this group are sturdy and readily understandable by any competent mechanic. It will be interesting to examine these devices each by itself so as to develop some grasp of how the entire equipment operates.

Master Steam Pressure Controller

The master pressure controller is primarily a Bourdon pressure gage of the pilot type; that is, it is active through only a small range of variation immediately above and below the standard pressure for which the device is set. This Bourdon tube responds to steam pressure at some central point in the piping system and moves a pointer at the end of which is attached a heavy pin, similar to a small hammer head, known as the presser pin. The apparatus is so designed that this presser pin moves up and down with steam pressure through a relatively small total distance corresponding to a small range of pressure variation, the displacement of the pin from the normal central position being proportional to the departure of the pressure from the standard.

The Second Step

The second element of the apparatus is a device whereby the position of this sensitive element is transformed into an electric current whose duration is dependent upon the rate of departure of pressure from normal. This mechanism is shown diagrammatically in Fig. 1. The stepped wedge block shown at the right is reciprocated horizontally through a fixed stroke by means of a cam driven continuously by a small electric motor. If the presser pin is in the standard position—that is, if no change of condition is called for—the wedge block, when it advances, receives the presser pin in its central depression (as at *B*, Fig. 1), and causes no motion thereof. If, on the other hand, the pressure is above normal, so that the presser pin is above its neutral position, the wedge block, when it advances, will catch the presser pin between one of the wedge block steps and the upper pusher plate, as shown at *C* in Fig. 1. If the deviation from standard is small, as indicated

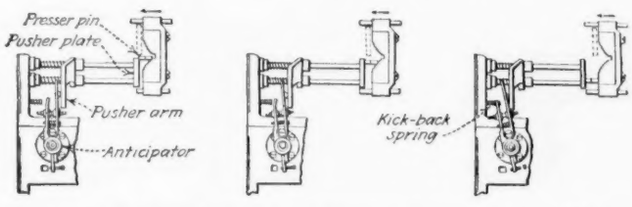


Fig. 2—Each pusher plate actuates a contactor with an "anticipator" mechanism, which takes account of the rate and direction of change of the controlled quantity

at *C*, the wedge block will come in contact with the presser pin late in the stroke, and the time during which the upper pusher plate is displaced will be short.

If the pressure is below normal, the presser pin will be in the lower portion of its range and will be caught in a similar manner by the lower half of the wedge block. At *D*, in Fig. 1, it is assumed that the deviation from normal is large. In this case the wedge block comes in contact with the presser pin early in the stroke, and the pusher plate is displaced to the left during a long period.

Fig. 2 shows the type of electrical contactor used in

connection with the master pressure regulator. This contactor is so designed that the contact is established immediately upon the beginning of motion of the pusher

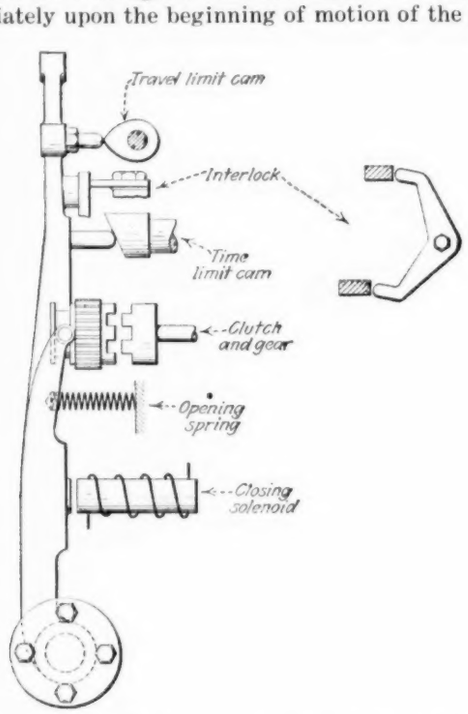


Fig. 3—The clutch lever is operated by solenoid and spring, with knockout cams and interlocks to safeguard its operation

plate, and continues throughout the motion of the pusher plate toward the left. When return motion begins, however, contact is immediately broken, the right-hand contact arm following the pusher plate in its travel to the right and the left-hand contact arm remaining where it is, except that for large displacements it is pushed back a short distance by the kick-back spring. This rear contact arm is mounted with a friction grip on a shaft that rotates approximately one revolution per hour, and accordingly the contactor is returned to its neutral position with the speed of the minute hand of a clock. The object of this mechanism, known as an anticipating mechanism, is to provide a time interval after a correction has been made to determine whether the correction has been sufficient before contact is again made for any considerable length of time.

These elements in the system close electric circuits to produce electric currents upon deviation of steam pressure from normal whether the pressure goes below or above normal. These currents are produced in appropriate circuits corresponding to the demand for an increase or decrease of air and fuel. The third element of the system is a mechanism whereby these electrical currents of varying duration are utilized for the control of motors driving equipment, or for the movement of dampers, etc.

This mechanism consists of a number of identical units, each for accomplishing one thing. That is, there is one train of gearing for increasing the speed of the induced-draft fan motor, another for decreasing its speed; still another for increasing and another for decreasing the speed of the coal feeder or stoker motors, and so on. These units are substantially identical, and an understanding of the action of the device can readily be had through the study of one unit.

Detailed Description of One Unit of the Mechanism

Fig. 3 illustrates diagrammatically the mechanical scheme employed to produce the desired results. In the first place, consider the operating lever shown at the left in Fig. 3. This is pivoted at its lower end, and near the center is connected to a jaw clutch carrying a spur gear. In the position shown, this spur gear and its half-clutch are idle, the other half-clutch being mounted on a shaft that is run continuously by electric motor drive. Near the lower end of the lever is a solenoid which, when energized, draws the lever to the right and closes the jaw clutch. This causes the gear to be driven by the shaft and, as will be seen later, actuates the controlling mechanism. For the moment it is desirable to describe the other attachments on this clutch lever. Immediately above the solenoid is a spring that throws the clutch open when the solenoid is de-energized. These two devices, the spring and the solenoid, furnish a complete operating device whereby the clutch is opened and closed in response to the closing and opening of a switch by the pressure-responsive mechanism already described. This, however, is not sufficient for completely reliable operation. In the first place it is necessary to make certain that the two clutches corresponding to opposite action cannot be engaged simultaneously; that is, the clutch for increasing the air supply and the clutch for decreasing the air supply must not be engaged simultaneously. This is safeguarded against by the use of an interlock. The increasing and decreasing clutch levers for any given quantity are always adjacent, and

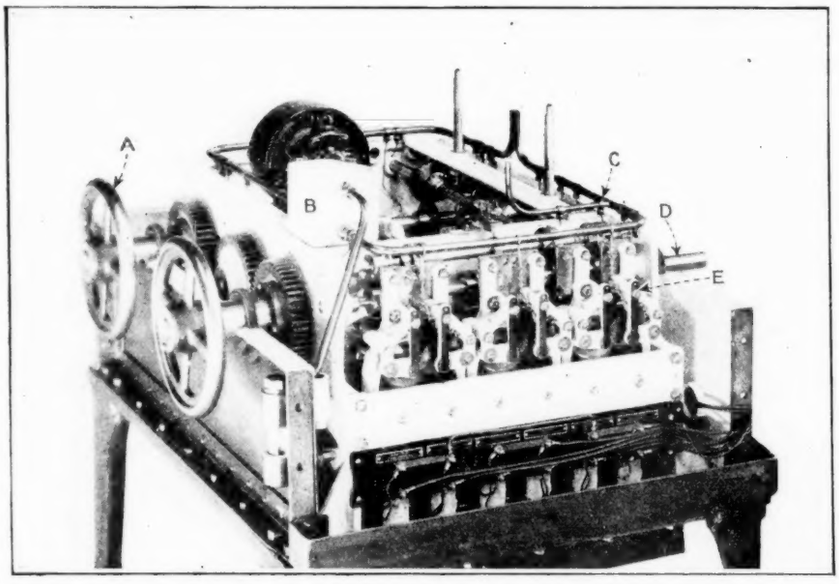


Fig. 4—Six clutch levers are lined up at one end of the gear box

At *A* is shown a handwheel for manual control in case of power failure or for readjustments. *B* is the oil reservoir, feeding to the gravity distributing system *C*. *D* is a drive shaft for a motor or damper controller. *E* is a clutch lever.

a small interlock lever is mounted as indicated in Fig. 3, so that when one such lever is in, the other cannot come in. In addition to this there are time-limit knock-out cams which force the clutches open after they have been engaged for approximately five seconds, even though the solenoids are still energized. This effectively

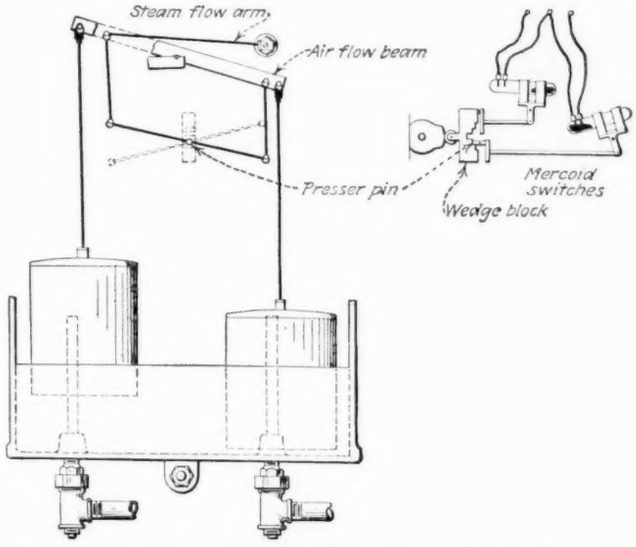


Fig. 5—The steam-flow air-flow control is similar to the pressure control, but the mechanism is somewhat simpler

safeguards against the action of residual magnetism or mechanical sticking of the equipment. Travel limit cams are also used to open the clutches at the limit of travel of damper or motor controller.

Through a simple gear train the action of the clutches is transformed into motion of a control shaft in one direction or another. The two driving shafts are running continuously in opposite directions, and according as one clutch or the other is engaged, the driven shaft will rotate in one or the other direction and thus adjust a damper or motor controller so as to give more or less air, coal, etc.

All this gear mechanism is mounted in a dust-tight steel case and is provided with a complete self-contained positive-feed lubricating system, as shown in Fig. 4.

The master steam-pressure control system thus far described actuates control units on each individual boiler in the plant, simultaneously changing both air and fuel feed rates for all of them.

Steam-Flow Air-Control

In addition to this each individual boiler has a steam-flow air-flow device that adjusts the quantity of air to maintain either a constant value of this ratio or a value that varies in some predetermined manner, so that the percentage of excess air supplied may be maintained constant or may be varied with boiler rating.

In the case of the steam-flow air-flow controller the presser pin occupies a position depending upon the ratio of air flow to steam flow. This is accomplished by mounting the pin at the center of a floating lever, one end of which responds to steam flow, the other to air flow. This mechanism is built into the regular steam-flow air-flow meter, as shown in Figs. 5 and 6, and involves only a small addition, with no material complication of the equipment. A simpler type of contactor is used, consisting of the tilting mercoid switch shown in Fig. 5. The anticipator mechanism is not needed in this case, because the control action is of a slower and more gradual nature.

The double control of air flow is accomplished through the use of a differential gear. Fig. 7 is a diagram of the gear train employed.

In connection with the steam-flow air-flow control, which maintains a controlled excess of air supply, it is to be particularly noted that it is not sufficient to maintain a fixed relation between the speeds of feeders and fans. The relation between feeder speed and rate of pulverized coal feeding is not rigidly fixed, and varies with changes in the moisture content of the coal, with wear of the feeder screw or other parts, as well as with the rate of change of feeder speed. Accordingly, any effective regulation must respond, not to the mechanical motion of parts, but to the actual results produced, in terms of per cent CO_2 in the flue gas, or steam-flow air-flow ratio, which has been shown to be a reliable equivalent of the CO_2 content of the flue gas.

Similarly, in the case of stokers the rate of coal feed is not strictly proportional to stoker speed, but the large mass of coal stored in the furnace has sufficient "fly-wheel" effect to make it possible to employ stoker speed

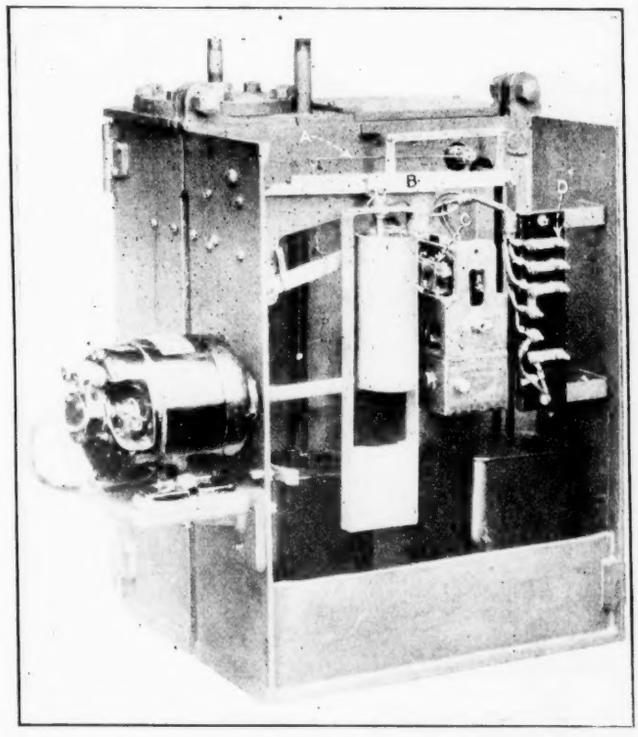


Fig. 6—An extension on the back of the meter casing houses the steam-flow air-flow control, and a small motor drives the wedge-block mechanism

as an operating control. Occasional hand adjustments serve to correct any accumulated discrepancies, as evidenced by the fire becoming too thick or too thin. The Bailey outfit, however, uses the steam-flow air-flow ratio for stoker-fired boilers to maintain the proper proportioning of air to fuel, as in the case of pulverized coal.

Inasmuch as the operating conditions are increasingly severe on the firebrick as the rate of combustion per cubic foot of furnace volume increases, it is often desirable to maintain lower percentages of CO_2 at high rat-

ings. Correspondingly, in the case of air-cooled walls at least, it is necessary to supply considerable excess air at low rating to avoid damaging the walls through insufficient cooling by air. Both of these conditions can readily be met in the air-flow steam-flow ratio control. Special controllers may be used when desired to maintain a given draft in the furnace, either constant or varying with rating, or to maintain any other operating detail in accordance with any desired schedule.

For the sake of safety there are limit stops provided to prevent operating conditions that produce serious smoke or danger of explosion. When the maximum air

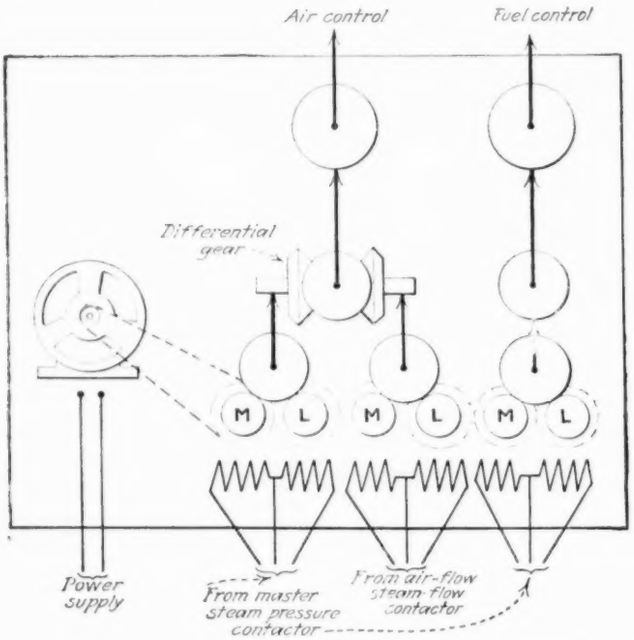


Fig. 7—A differential gear permits dual control of air flow

supply is attained, an interlock prevents the supply of additional fuel. When, on the other hand, the fuel rate is reduced to its lowest limit, an interlock prevents further reduction of the air supply. There are also overtravel limits for controllers, dampers, etc.

Switches are provided whereby, through the simple turning of a knob, any one of the automatic features may be thrown out of action and displaced by manual push-button control. Should the supply of electric current to the control mechanism fail altogether, control can still be effected through the medium of handwheels on the individual boiler boards.

Instruments and control handwheels and switches are mounted on panels, one for the master pressure control and one for each boiler.

Other Control Systems

Several systems have been developed for combustion control, some of which have been described in earlier issues of *Power*. A general discussion of control by Charles H. Smoot appeared in the issue for March 6, 1923 (p. 354), and the Smoot pneumatic control apparatus was described on May 16, 1922 (p. 771). The Benjamin electrical control scheme was covered by an article on Jan. 8, 1924 (p. 46). The Hagan combustion control regulator was described on Oct. 21, 1919 (p. 610), and the Enco apparatus on May 11, 1926 (p. 711).

Operated Same Engines for 59 Years

THIS is the story of a man and some engines. The man is Andrew Kidd, born in 1843, still hale and hearty. The engines are those still running in the mills of the Burden Iron Works, Troy, N. Y., some installed in 1862, some later.

The story starts at Lochwinnoch, Scotland, where Andrew Kidd first saw the light eighty-three years ago. His engineering experience began in 1863, when he took a job as fireman on a boat sailing out of Glasgow. Later he operated beam engines in a cotton factory.

The Civil War had been over but a short time when Andrew Kidd sailed for America in 1867. On July 21 of that year he began work for the Burden Iron Works. His first job there was running a hoisting engine. He was made second engineer in 1873. In 1882 he became chief engineer, which position he held until his retirement on pension April 15, 1926, after 59 years of continuous service in the same plant.

This plant, by the way, has much of romance in its history. Back in 1836 its founder, Henry Burden, built a great overshot waterwheel 61 ft. 9 in. in diameter to furnish power for rolling wrought-iron bars. The face of this wheel was 22 ft. wide, the buckets were 5 ft. 9 in. deep. From that day to this the company has always been engaged in the manufacture of wrought-iron products—merchant bar, horseshoes, iron boiler rivets, locomotive staybolts, etc.

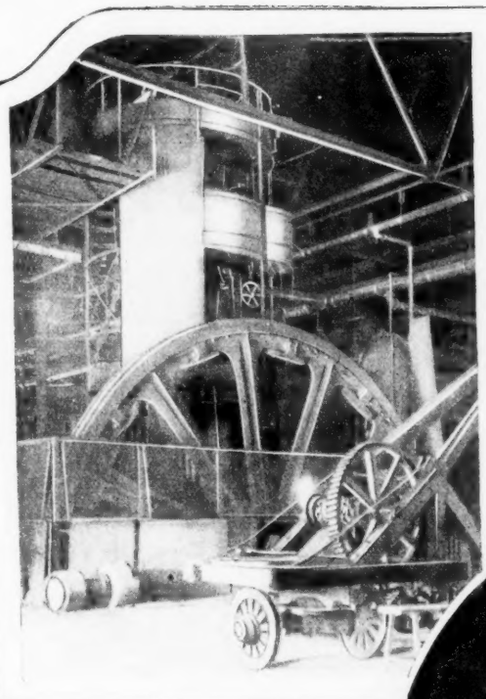
Long as has been Andrew Kidd's service with this company, it is exceeded by that of four vertical Corliss engines installed in 1862, and still in daily operation. One of these, shown in Fig. 5, is belted to a lineshaft driving blast fans. This is a 23x36-in. engine which develops 150 hp. at 60 r.p.m. It has been run day and night since its installation. The only major repair has been the replacement of a cylinder in 1880, made necessary by an accident to one of the rings.

In Fig. 2 Andrew Kidd is seen standing on the cylinder platform of a 30x36-in. vertical single-eccentric Corliss driving two trains of rolls. This engine, which develops 430 hp. and takes steam at 80 lb. pressure, is one of three installed in 1862. The only important repair ever made on it was the replacement of the piston many years ago. The cylinder has been rebored twice.

The other engines illustrated, while not as old as those just described, are of considerable historic interest. The 40x60-in. Corliss forge engine shown in Fig. 1 was installed in 1882, replacing a 42x42-in. Corliss installed in 1868.

The Worthington pump shown in Fig. 3 has supplied the works with water since 1882. It is a duplex tandem compound pump with a capacity of three and one-half million gallons per 24 hours against a pressure of 30 pounds.

After a life of hard work Mr. Kidd is today vigorous in mind and body and is active in sports and recreations, such as bowling and fishing. He is universally loved and respected by his old associates in the Burden Iron Works. Incidentally, he has been a subscriber to *Power* without a break from the first issue. His son, Andrew Kidd, Jr., is a consulting engineer in the City of New York.



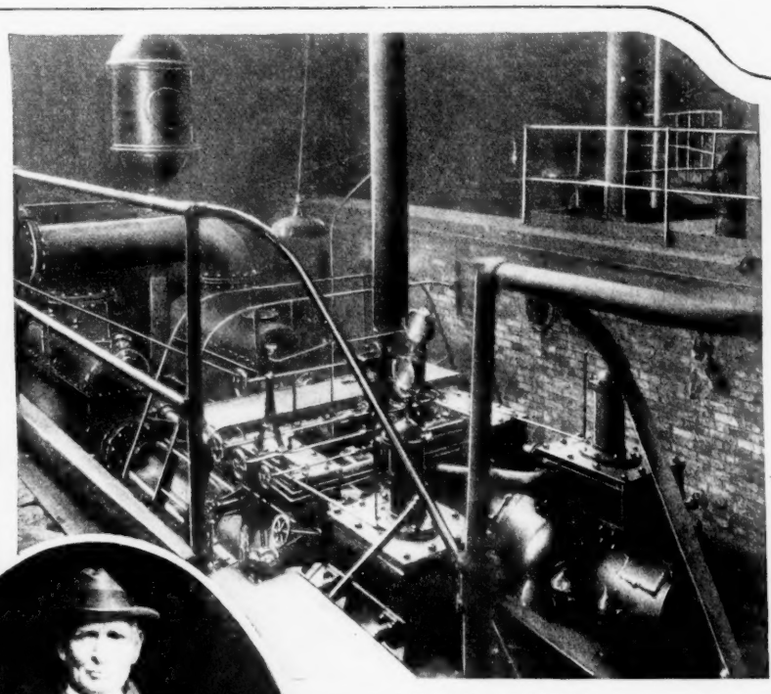


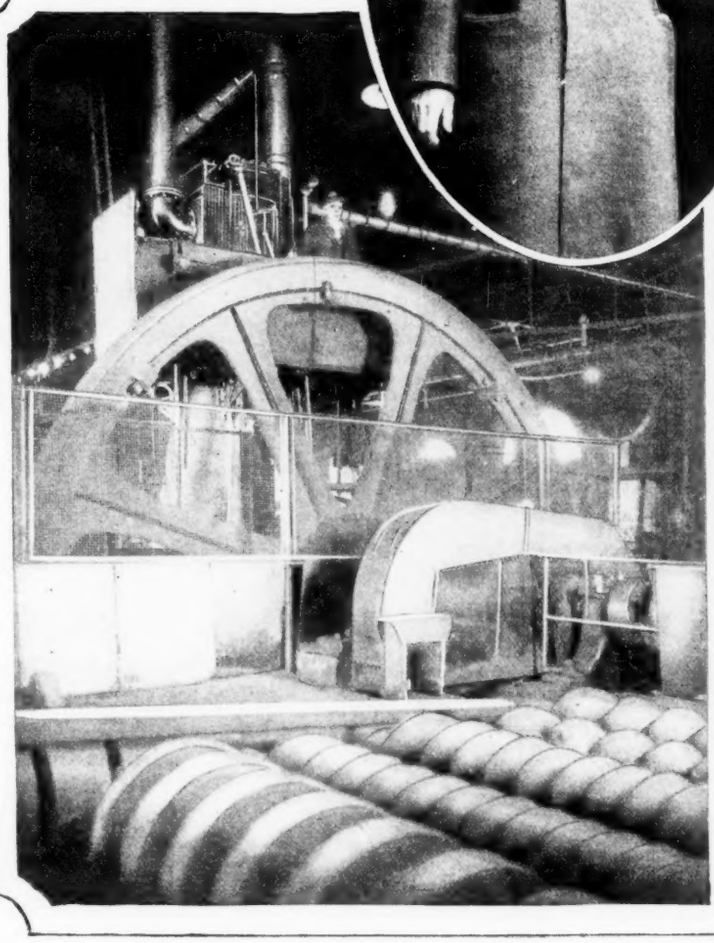
Fig. 1 (Above)—Forge engine installed in 1882

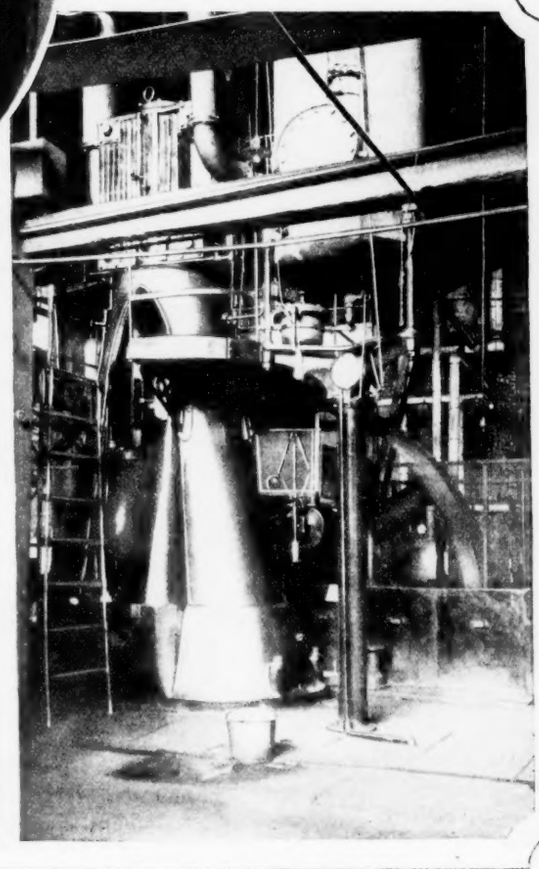
Fig. 2 (Below)—One of three rolling mill engines in daily operation since 1862

Fig. 3 (Above)—Duplex compound pump installed in 1882

Fig. 4 (Left)—Andrew Kidd shortly after his retirement

Fig. 5 (Below)—This vertical Corliss has driven blast fans since 1862





Belt Conveyors and Skip Hoists

By W. W. SAYERS
Chief Engineer, Link Belt Company, Chicago

ADVANTAGES and limitations of belt conveyors for handling coal, types of idler used and capacity range. This is the third of a series of five articles on coal handling. The first, entitled "Modern Methods in Coal and Ash Handling," appeared in the July 27 issue, and the second on "Elevators and Conveyors for Coal Handling" in the August 3 issue.

BELT conveyors are so called because a canvas or rubber belt is used to carry the material. They are installed horizontally, or at inclinations up to 18 or 20 deg., or both inclined and horizontally, and are suitable for conveying small or lump abrasive or non-abrasive materials. The load is delivered from the belt while passing around the discharge pulley or over a stationary or movable tripper, into overhead bunkers, separate bins or to other conveyors. The traveling tripper is used only on the horizontal section of the belt.

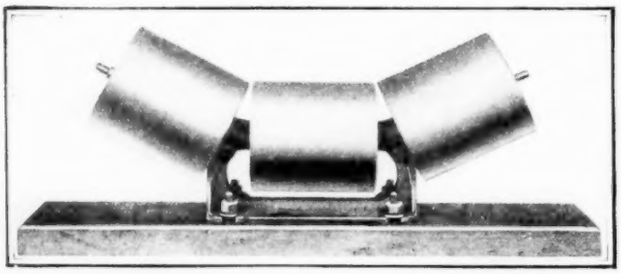


Fig. 1—Troughing the carrying run of belt

One or more pulleys, located at the most convenient points, are used to drive the belt. Between the head and foot pulleys the intermediate sections of the belt are carried on idlers made up of small pulleys or rolls. Usually, the idlers for the carrying run have the rolls arranged to trough the belt, as in Fig. 1, to prevent the material from spilling over the sides and to increase the carrying capacity of the belt. Where the belt is not troughed, the idlers consist of a single roll, Fig. 3, or several short rolls, mounted on a through shaft carried by end bearings. Frequently, idlers have a single roll with bell-shaped ends for slightly troughing or turning up the edges of the conveyor belt.

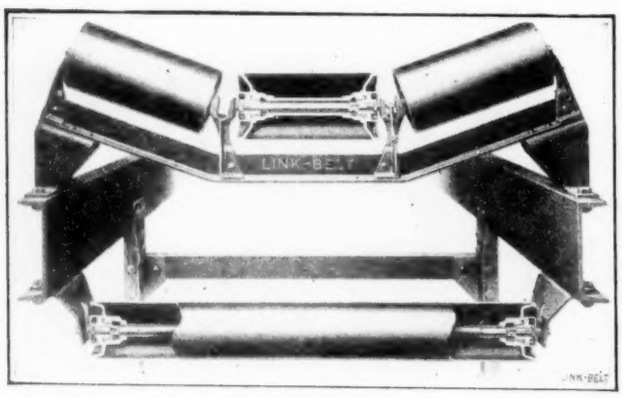


Fig. 2—Troughing idler with roller bearing

The multi-roll idler, consisting of a number of pulleys or rolls assembled to form a trough for the belt, has greater carrying capacity than the flat types and provides a better means of handling lumpy material. However, until within the last few years the latter type of idler was most commonly used as it was better suited for general application. It, as well as the other types, usually was provided with grease lubrication, although self-oiling bearings are advantageously and frequently used with single-roll idlers.

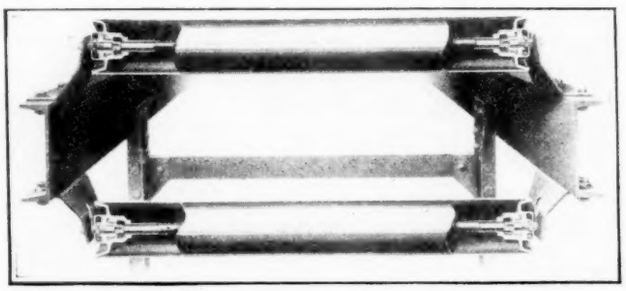


Fig. 3—Single flat type roller

Because of the number of replacements necessary during the life of the installation, the belt is the most expensive part of a belt conveyor, so that it should be protected as much as possible from injury. All rolls over which the belt passes must be smooth, with true running, rounded edges; they must be well balanced and turn easily under all conditions of service. Each roll must turn constantly while the belt is moving, as

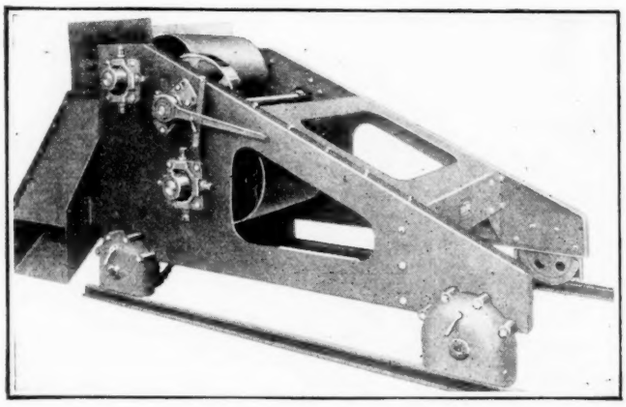


Fig. 4—Self-propelling belt tripper

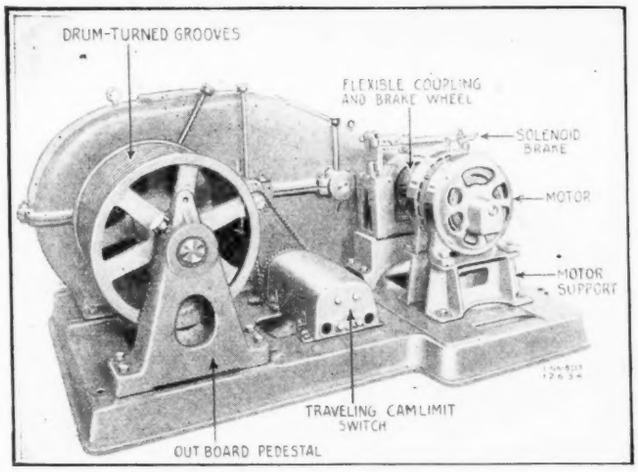


Fig. 5—Typical hoisting unit

rolls having bearings that freeze and stick, soon wear out and tend to cut the belt.

It is apparent that the idler roll is the key to the successful and extended operation of the entire belt conveyor. Upon its ease of operation largely depend the efficiency and cost of handling material.

Belt-conveyor service at the power house demands a bearing that will carry heavy loads, and as some of the rolls are on an inclined shaft, the bearings for these rolls must also carry a thrust load and at the same time must often run with little attention. Timken tapered roller bearings are used in the anti-friction idler which is shown in Fig. 2. This not only effects a considerable saving in power, but makes possible the use of longer conveyors than heretofore have been practical. In passing it may be of interest to point out that anti-friction bearings, pillow-blocks, take-ups and trippers also have been designed and are now in many plants.

Belt Conveyors Require Less Power Than Other Types of Elevating Machinery

Regardless of the type of idler used, belt conveyors require less power for handling a given amount of material than other types of elevating and conveying machinery and provide an excellent equipment for use where the conditions are suitable. Since the manufacturers of belts have so greatly improved their product during the last few years, the increase in the life of the belt and the quantity of material that it will handle before requiring replacement, has made belt conveyors economical in maintenance as well as power.

Belts are manufactured in widths varying from 12 to 60 in. with capacities of from 10 to 2,000 tons per hour. The speeds of belts vary from 100 to 600 ft. per min., but the most usual speed for belts of average width is 300 ft. per min. Depending upon the service required, ordinarily, belts are made from four- to eight-ply. Rubber belts are provided with a rubber covering $\frac{1}{32}$ to $\frac{1}{8}$ in. thick on the carrying side, to protect the fabric from the abrasive action of the material handled and from water and moisture.

The driving pulley or pulleys are usually rubber lagged to give additional driving friction between the belt and the pulley. Where the belts are extremely long and the load heavy, tandem or hugger drives are used to secure the necessary driving friction.

Belt conveyors are furnished in lengths varying from a few feet up to several thousand feet, and are especially applicable where large quantities of material, say 100 tons or more per hour, are to be conveyed a considerable distance. The most common application of belt conveyors in a power house is to convey and distribute the coal to overhead bunkers. A traveling tripper such as is shown in Fig. 4 is used to discharge the material to the bunker. Occasionally, belts are used for conveying ash.

Where the material must be elevated a considerable distance, usually there is not sufficient room to employ belt conveyors, owing to the small angle of inclination at which they can be operated. Even where space is available, for the long belts required the first cost is high, but the operating cost is practically the same as that for the pivoted-bucket carrier or skip hoist.

The Skip Hoist for Coal and Ash Handling

A skip hoist is a useful type of equipment for handling coal and ashes. Where the quantity of ash is sufficient to require a separate unit for handling, and where the ash contains large clinkers, the skip-hoist is especially efficient. Where the lift is approximately 100 ft. or more, it can be used advantageously for handling coal, as it is less costly than the heavy chains or long belts required to meet the high lift.

The skip or bucket is built in capacities of from 20 to 400 tons per hour. The skip is carried on rollers and by a bail attached to a steel cable leading to the winding drum of the hoisting machine which is driven by a motor. In the hoisting and lowering operations the bucket is controlled either automatically or manually, there being a slight pause between while the skip or skips are being loaded or discharged.

As shown in Fig. 5, the hoisting machine is a self-contained unit, consisting of a winding drum mounted on a heavy shaft, driven through gears usually running in a bath of oil in an inclosed housing. The sub-base carries the motor, solenoid brake and traveling cam limit switch which controls the hoisting and lowering

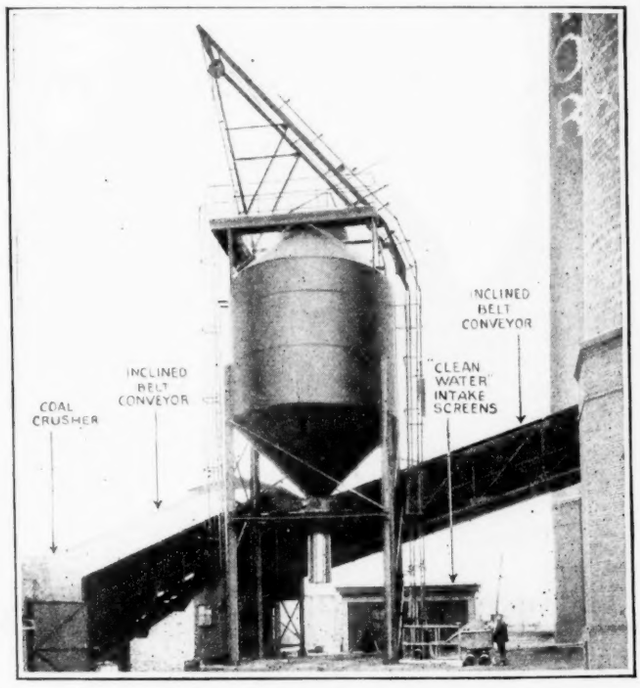


Fig. 6—Skip hoist installation for handling ash

operations. The motor operating the hoisting machine is so controlled by a push button that it automatically hoists, discharges and returns the skip to its filling position, where it remains until again loaded. The attendant again pushes the button for the next cycle of operation.

When handling ash, small cars, of capacity slightly less than that of the skip, are dumped directly into the bucket, as in Fig. 6. For this service manual loading is usually employed.

Skip Hoist for Loading From Track Hopper

When handling coal from track hoppers furnishing a continuous supply, a loader of the type shown in Fig. 8, is provided for automatically filling the skip. The loader is actuated by the skip. In automatic operation a push button starts the skip which, after being started, remains in constant operation, until the button is pushed into its off position by the attendant.

For high lifts the skip hoist has the advantage of being so controlled that it enters the loading and discharging zones at slow speed, traveling at the comparatively high speed of from 200 to 300 ft. per min. between the loading and dumping points.

For installations of small capacities, 20 to 40 cu.ft., a single skip, not counterweighted, is generally used; but with skips having capacities of over 40 cu.ft., provision is made for counterweighting the dead load of the skip plus 50 per cent of the weight of the material, reducing in this way the size of the motor that would be required if counterweights were not used.

Where large quantities of material are handled and space permits, two skips are operated by a single hoisting machine, the cables being so arranged on the drums that one skip is hoisting while the other is lowering; thus the dead weights of the skips balance each other. In this case the maximum load on the motor is that required to hoist the contents of a single skip. This arrangement has a further advantage in that a given capacity can be secured by using two skips of half the size required if but one were employed.

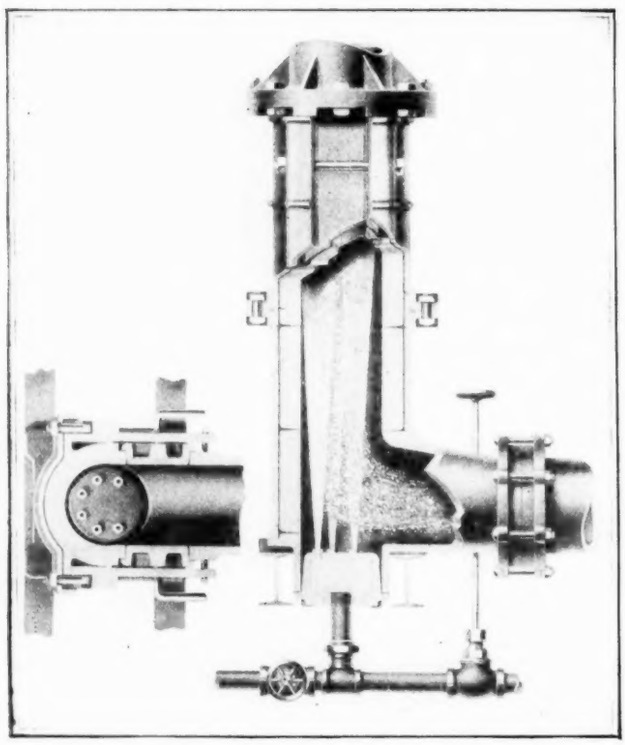


Fig. 7—Steam-jet ash conveyor

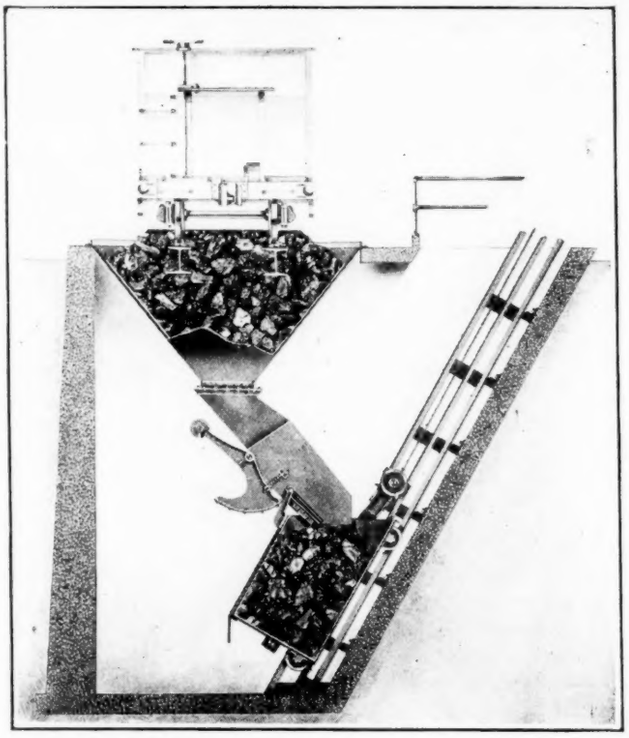


Fig. 8—Automatic loading skip

Steam Jet System

For handling ash the steam-jet system is sometimes employed for elevating and discharging into an overhead bin. It consists of a cast-iron pipe, Fig. 7, provided with renewable shoes at the turns for taking care of the rapid wear at these points. A jet of steam injected into the pipe, creates suction. The ash is raked into openings, carried along by the suction of the steam, and delivered to an overhead bin.

This method is especially adaptable for conditions necessitating a tortuous path of travel and for places where there is not sufficient room to install other types of elevating and conveying equipment.

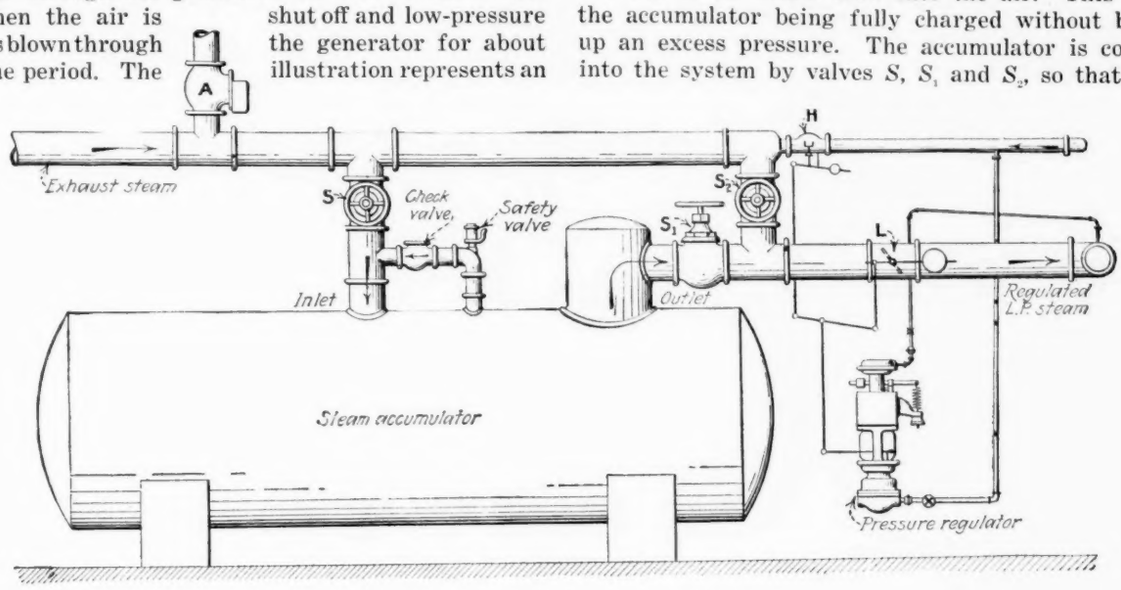
For alternating-current, voltage and current transformers shall be used for all instruments, meters and relays connected to circuits of over 150 volts, in order to reduce the voltage on instrument wiring on the rear of the switchboard panels, which must necessarily be closely grouped. Exceptions to this rule are on 440 volts, which may be used directly on relays and contactors in unattended stations. Voltages up to 250 may be used directly on instruments mounted on isolated panels and where no potential buses are required.—*Electric Power Club Safety Standards.*

Long experience under many different conditions has proved that with a water rheostat used on high voltage, spacing of the electrodes does not have any appreciable effect on the amount of current, when using fresh water such as the forebay of a hydro-electric plant. It seems to be very largely a question of surface contact.

Accumulators Used to Equalize Exhaust-Steam Demands

A STEAM accumulator consists of a large tank, partly filled with water and connected to some point on a steam piping system. The purpose of the accumulator is to store steam by increasing the temperature of the water during periods when there is an excess of steam, and to supply steam when the demand is heavy.

Low-pressure accumulations are used on exhaust-steam systems to store steam when there is an excess, to be used when there is a deficiency. A good example of this is that used on a turbine-driven blower for blowing a water-gas generator. In this class of work air is blown through the generator for two or three minutes, then the air is shut off and low-pressure steam is blown through the generator for about the same period. The illustration represents an application made by the Smoot Engineering Corp. where the regulator renders operation automatic.



Connections of accumulator and automatic regulator to exhaust-steam line

The exhaust-steam line in the figure connects to the exhaust of the turbine and the regulated low-pressure steam line connects to the gas generator. When the generator is having air blown through it, there is no demand for the exhaust from the turbine and it goes into the accumulator to raise the temperature of the water. The accumulator is filled with water to about 75 per cent of its capacity. The steam is blown into the water through a series of nozzles in such a way as to maintain the temperature of the water almost equal to that of the steam, with which it comes in contact. During the period of storage the back pressure on the turbine is increasing, as is the temperature of the water in the accumulator.

When the air valve is closed and the steam valve is opened on the producer, the load is reduced on the turbine and the demand for low-pressure steam increases above that which can be supplied by the turbine, so that the exhaust pressure drops, and the water in the accumulator begins to flash into steam to supply the deficiency. Although the pressure in the accumulator varies through a range of 5 to 12 lb., the pressure in the regulated low-pressure line is maintained practically constant by the pressure regulator operating the low-pressure regulating valve *L* and the high-pressure regulating valve *H*. As the pressure drops in the accumulator, the pressure regulator opens the low-pressure regulating valve to maintain the pressure constant in the low-pressure main to the generator. When this valve is full open, the regulator begins to open the high-pressure regulating valve and any deficiency in low-pressure steam is supplied by live steam. Closing the steam valve at the producer, causes the pressure in the regulated steam line to rise and the regulator closes the high-pressure regulating valve *H* and starts closing the low-pressure regulating valve *L*, and the previously described cycle is repeated.

Should the exhaust pressure build up above a predetermined value, an atmospheric relief valve *A* opens and lets the excess steam blow into the air. This insures the accumulator being fully charged without building up an excess pressure. The accumulator is connected into the system by valves *S*, S_1 and S_2, so that it may be bypassed at any time for inspection or cleaning, thus permitting uninterrupted operation of the plant.

A feature of an accumulator that is not generally appreciated, is that it is practically a 100 per cent water separator. No matter how wet the exhaust steam absorbed by the accumulator, the steam given off, when the pressure is reduced, will contain on the average less than one per cent moisture. The reason for this is that the turbulence of the water, when it flashes into steam in the accumulator, is not nearly so violent as in a boiler. The excess water collecting in the accumulator must be drained off, and this provides a means of removing any oil that may be carried in by the exhaust steam. Where steam turbines are used, oil in the exhaust is of a negligible quantity, but with steam engines it may become of vital importance. In the accumulator the oil will have a tendency to float on top of the water, and can be largely removed.

Water systems have such a comparatively low ground resistance that where they are in proximity to pipe or plate grounds, it has been found that a difference of potential will exist between the two during ground fault conditions on electric circuits, which constitute a hazard to life unless the water system and pipe or plate grounds are connected together.

*Boiler Feed-Water Purification—VI**

Zeolites Explained†

What Zeolites Are and How They Work—Natural and Synthetic Zeolites—Rapid and Slow Regeneration—Porous and Non-Porous Materials—Zeolite Softeners—Use of Salt in Regeneration

By SHEPPARD T. POWELL
Consulting Chemical Engineer, Baltimore, Md.

SOFTENING water by base-exchange silicates, termed zeolites, consists in passing the water through a bed of material that possesses the property of removing the calcium and magnesium from the water and replacing these substances with sodium or potassium. The exchange takes place fairly rapidly, so that hard water in passing through the mineral may be completely or almost completely softened.

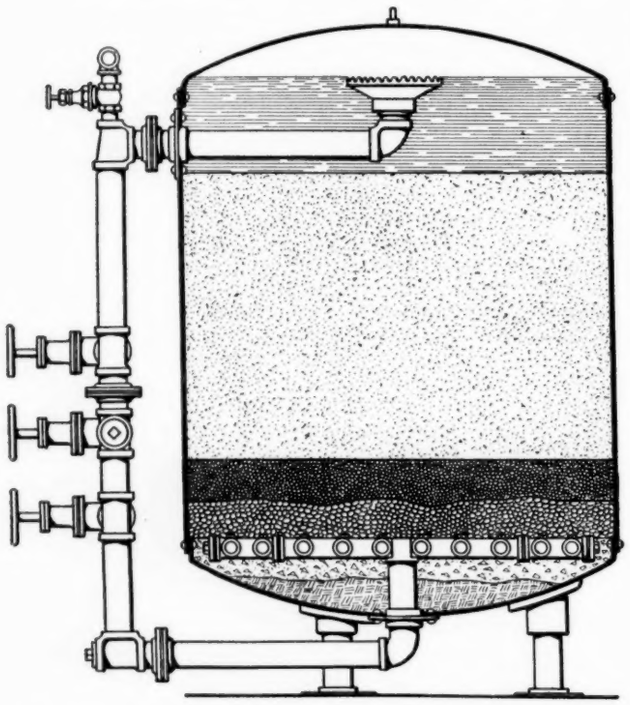


Fig. 1—Sectional diagram of a vertical industrial zeolite softener unit (Wayne)

A zeolite mineral will continue to soften water until all or practically all the sodium has been exhausted from it. When this condition results, the zeolite may be regenerated, that is, have the sodium replaced that has been removed during the softening process. Regeneration is effected by treating the mineral with a solution of sodium chloride (common salt). The reverse action then takes place and the calcium and magnesium extracted from the water by the zeolite passes into the brine solution and the sodium is taken up by the mineral.

The term zeolite through common usage has become divorced from its original meaning. Zeolite, as the word was used originally, indicated certain specific minerals, namely, a group of hydrous silicates. At present, this name is applied not only to these silicates, but to a number of base-exchange silicates that are artificially produced. There is a fairly large number of natural base-exchange minerals, and several products are manufactured that possess base-exchange properties. The chemical formulas of different materials vary, but most of them are hydrous silicates of sodium and aluminum. The sodium being released easily, is replaced by other bases forming new combinations. This permutation action is the distinguishing characteristic of all zeolites.

The hypothetical reactions that take place in softening water by these substances may be expressed as follows:

(1) Na_2 zeolite + $CaCO_3$ = Na_2CO_3 + Ca zeolite
(Sodium zeolite; Calcium carbonate; Sodium carbonate; Calcium zeolite)

(2) Na_2 zeolite + $Ca(HCO_3)_2$ = $Na_2(HCO_3)_2$ + Ca zeolite
(Sodium zeolite; Calcium bicarbonate; Sodium bicarbonate; Calcium zeolite)

(3) Na_2 zeolite + $CaSO_4$ = Na_2SO_4 + Ca zeolite
(Sodium zeolite; Calcium sulphate; Sodium sulphate; Calcium zeolite)

(4) Na_2 zeolite + $Mg(HCO_3)_2$ = $Na_2(HCO_3)_2$ + Mg zeolite
(Sodium zeolite; Magnesium bicarbonate; Sodium bicarbonate; Magnesium zeolite)

(5) Na_2 zeolite + $MgSO_4$ = Na_2SO_4 + Mg zeolite
(Sodium zeolite; Magnesium sulphate; Sodium sulphate; Magnesium zeolite)

The foregoing reactions should indicate that a fairly large number of combinations may result when water containing various salts of calcium or magnesium are filtered through a bed of base-exchange mineral.

The reaction that takes place when the bed is regenerated with common salt is as follows:

Ca zeolite + 2NaCl = Na_2 zeolite + $CaCl_2$
(Calcium zeolite; Sodium chloride (common salt); Sodium zeolite; Calcium chloride)

or

Mg zeolite + 2NaCl = Na_2 zeolite + $MgCl_2$
(Magnesium zeolite; Sodium chloride; Sodium zeolite; Magnesium chloride)

A number of terms have been coined to describe the

*Previous installments have covered the following subjects: July 6, "Natural Waters and Their Impurities"; July 13, "Getting Rid of Impurities by Sedimentation and Coagulation"; July 20, "Filtration by Gravity and Pressure Filters"; July 27, "Softening Water by Chemicals"; Aug. 3, "Hot Process Continuous Softeners."

†The discussion of zeolites will be continued in the next article, which will deal with the economic features and list also the relative advantages of zeolite and chemical precipitation softeners.

various zeolites used in water softeners, and much controversy has arisen as to their proper classification. The terms used are (a) natural, (b) artificial, (c) synthetic, (d) slow regeneration, (e) rapid regeneration, (f) porous and (g) non-porous zeolites. It is to be expected that confusion exists frequently in the minds of many persons as to the proper interpretation of these terms. Under the condition, it appears that a brief discussion of these terms is warranted.

Natural Zeolites

The phrase "natural zeolites" in its application to base-exchange water-softening substances is somewhat of a misnomer, since it does not describe adequately the zeolite material used for this purpose. There are many minerals found in various parts of the world that possess the power of permutation with respect to the exchange of bases. These materials, although they may be used, require processing before they are satisfactory for water softening. The most important deposits of base-exchange silicates are greensand or glauconite, bentonite and kaolin. There are extensive deposits of greensand in the southern part of New Jersey. The deposits of bentonite from Ardmore, South Dakota, have been used for some time for water softening.

The processing of base-exchange silicates to improve them for softening water is something of a trade secret, although the general details of working up the substance are fairly well known. The greensand or other form of natural mineral is mined generally by means of power-driven scoops or shovels. It is then heated in order to increase its hardness and is finally crushed and graded for size. In some cases the mineral is treated with caustic soda during the processing.

Synthetic zeolites have been manufactured for a number of years. The materials may be prepared by fusing hydrated oxide of aluminum, with sodium carbonate, potassium carbonate and kaolin or similar minerals, or by precipitation of certain sodium and an aluminum salt from a solution of sodium silicate. The precipitate obtained in this way is dried at a temperature sufficiently low so as not to remove the water of hydration.

The terms "rapid regenerating" and "slow regenerating" are applied to characterize the relative time rate of exchange of sodium from the brine solution. There is little reason for the adoption of these phrases to characterize water softening zeolite since regeneration is but one of a number of phenomena which take place in the operation of this form of water treatment.

The terms porous and non-porous zeolites have been suggested as being more accurately descriptive since these terms characterize the physical structure of the substance upon which the functioning of the material depends. There is apparently far more scientific justification for this classification.

A number of theories have been advanced to account for the softening of water by base-exchange silicates. It is fairly well established that the phenomenon is largely a surface action. The greater the surface area of the zeolite that is exposed to the water, therefore, the more effective it will be. It is a well-known fact that the smaller the size of the particles the greater their combined surface area will be for a given weight of material. Relatively large surface areas may be obtained also if the base-exchange material contains channels or passages. These two properties constitute the major differences in the various grades of zeolitic material used for water softening purposes.

The non-porous material is not affected materially by slight amounts of suspended matter that may be present in the raw water; it is regenerated more rapidly and may be cleaned more thoroughly by back-washing. Porous zeolites generally function well with clear water and under some conditions have a higher water softening capacity for a given period than non-porous zeolites. They cause trouble frequently, however, since their active properties may be reduced greatly owing to fine suspended solids closing the pores of the mineral. Difficulty is experienced with either type when the size of the grains becomes so small that they are carried through the underdraining system of the softener.

The history of zeolitic water softening has several interesting aspects. Although the purification of waters by these materials is comparatively recent, the properties of these interesting minerals were the subject of investigation as early as 1850.

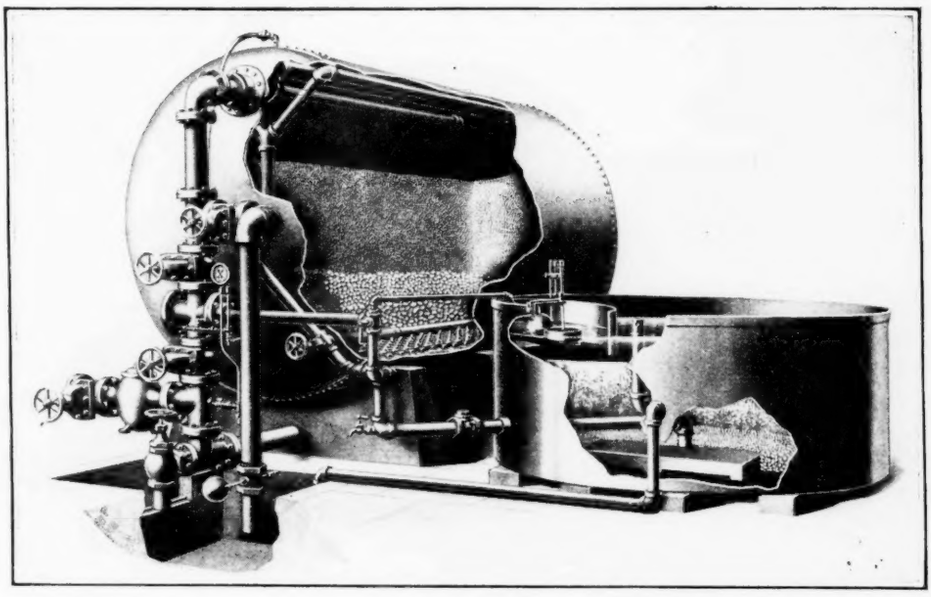


Fig. 2—Sectional view of horizontal zeolite softening plant (Permutit)

In 1906 Robert Gans, Germany, was granted a patent for the manufacture of artificial zeolite for water softening purposes. From that time base-exchange materials have been employed to soften water for industrial uses.

The equipment used in a zeolite water softener is similar in appearance to a pressure filter, although the operation is fundamentally different from filtration. The base-exchange mineral is contained in a steel tank and the mineral bed is supported on a gravel bed beneath which is the underdraining system.

Raw water enters generally at the top of the unit and the soft water is discharged from the bottom. The salt or brine solution for regenerating the zeolite is passed into the softener at the bottom or top and is distributed through the bed by the underdraining system. Practically all of the softeners sold at the present time are operated under pressure.

In Figs. 1 and 2 are shown sectional views of a horizontal of one make and a vertical softener by another manufacturer. The softeners are operated for a given length of time, and at the end of the run one unit is cut out of service and back-washed with clean water. This is done to remove any suspended solids that may have collected on the surface of the zeolite.

After the washing has been completed, sodium chloride solution (brine) is run into the softener. In some installations the brine is passed in at the bottom, and in other installations it enters the top. The salt solution is in contact with the zeolite for a time and is

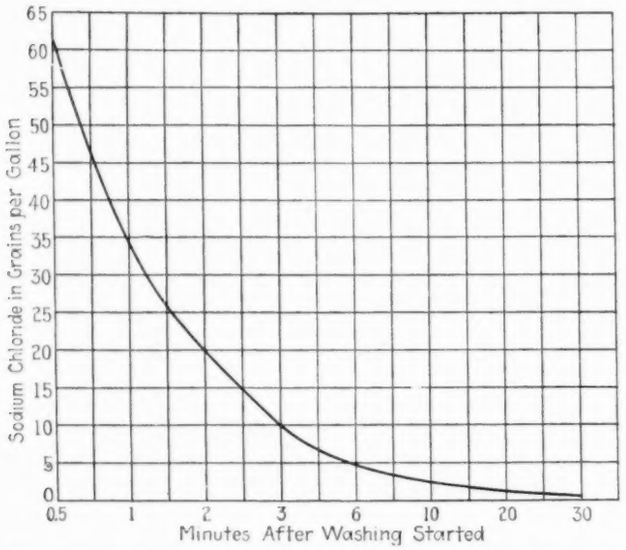


Fig. 3—Reduction of salt in water after back washing a base-exchange material

then drained from the unit. The softener is washed with enough clean water to flush out any excess salt, and it is then ready for service. The time of regeneration depends on the structure of the zeolite.

The method of conducting the salt solution varies in different installations. In some appliances the solution is siphoned from the brine tank into the zeolite bed and other units discharge the salt into the bed by gravity. A third method is to inject the solution. It is customary practice to employ a saturated salt solution for this purpose. Provision is made in some installations for the return of the brine solution to the brine tank after each regeneration period. This is done in order to reclaim some of the salt which may not have been fixed in the mineral. In other types the brine solution is discharged to the sewer after the regeneration process has been completed. The brine tanks are built of either steel or wood. The capacity of the brine tanks varies materially, depending upon the method of operation. Some installations are equipped with tanks to hold a sufficient quantity of salt solution for twenty to thirty regenerations.

The method of preparation of the salt solution differs with the type of softeners. The solution may be made up daily or in sufficient quantity to last two or three weeks. The quality of salt used is the ordinary grade of rock salt. It should be fairly free from magnesium and should not contain any appreciable amount of insoluble matter.

The quantity of salt required for regeneration varies with the hardness of the water and the volume of water softened between regeneration periods. Manufacturers have striven to reduce the salt consumption required to recondition the mineral since this is the principal item of cost of the process. The salt requirements with different minerals range from four-tenths of a pound to one pound per grain of hardness removed per one thousand gallons of water treated. The completeness of washing of the salt from the bed after the reconditioning process has been completed is an important factor. Sufficient water should be used to discharge all the salt, but the washing period should not be carried beyond this point, since it is a waste of water. The time required for reflushing varies from five to fifteen minutes. The flushing out of the brine may be controlled manually or automatically by passing a measured quantity of fresh water through the apparatus.

The rate of removal of salt from a zeolite softener after regeneration is shown in Fig. 3. It will be noted from this curve that at the end of ten minutes the water leaving the softener contained approximately 2½ grains per gallon of sodium chloride, equivalent to about 43 parts per million. The raw water supply contained 8 parts per million. Most softeners are back-washed for four or five minutes since the small amount of salt that is present at the end of this period is generally not objectionable.

Welded Pipe Neck Is Patented

In an article on "Welding in the Design of Industrial and Power Piping," by Lewis J. Sforzini, which appeared in the July 20 issue, one of the illustrations was of a reinforced pipe neck. The author states that he has been informed that this design is patented by the Pittsburgh Piping & Equipment Co.

The author has called attention to a slight error in Installment No. 3 of the feed-water series now running. On page 94 of the July 20 issue, just under Fig. 4, the text reads, "Filter units are built in two forms, horizontal and vertical. The former is adaptable primarily for filtering relatively small amounts of water and the latter where greater amounts are required." The words horizontal and vertical in the first sentence should be interchanged.

When rebabbitting motor bearing shells, it is always advisable to tin the inside surface of the shell first. This tinning should be done with wiping solder having a low melting point, and the temperature of the shell should be above the melting point of the solder when the babbitt is poured.

Carefully written detailed instructions describing the plant equipment and the safe and proper methods for its operation and maintenance, and calling attention to the specific hazards of the station equipment, are a valuable help in training the personnel in accident prevention.—*N.E.L.A. Report on Accident Prevention.*

Time to Resuscitate the Indicator

HOW many engineers under forty years of age know how to apply a steam-engine indicator and interpret the diagrams obtained? Thirty years ago the indicator was a valued instrument and no man considered that he was really up-to-date until he possessed one, immediately upon which he became the oracle to whom neighboring engineers turned when their engines began to cut capers. Indeed, many became experts and earned excellent fees by traveling about adjusting the valve gears of uneconomical engines upon a basis of their being paid a part of the saving made.

It may be true that the reciprocating engine is no longer the predominating prime mover, but there are millions of horsepower still in use, and last year over a half million more horsepower was installed.

The opportunity to better engine performance still exists, and it is the engineer's duty to make use of the indicator again. Many discuss with more or less learning the ways and means of increasing the boiler efficiency a small percentage through the installation of new apparatus or through better firing methods, when at the same time the indicating of the engine would reveal a possibility of reducing the steam consumption by twenty-five per cent.

The indicator is by no means an instrument for the exclusive use of steam engines; the thousands of ammonia compressors, air compressors and oil engines offer opportunities to engineers who are striving to reduce power costs.

The Power Conference at Basel

RECENT advices from abroad indicate that the Power Conference to be held at Basel in September is assuming international proportions and character rather than those of a sectional meeting as originally planned. In fact, it is commonly being referred to in the technical press as the "Second World Power Conference."

At the close of the first conference at Wembley in 1924, it was suggested that a second conference be held in 1930, and a permanent international executive committee was chosen, through which suggestions and plans for future meetings could be taken up. This committee, representing sixteen countries, met in London just a year ago, and in response to an invitation from Switzerland to hold a second conference in connection with the "Exposition for Inland Navigation and Hydraulic Power" at Basel this summer, decided that the time was not ripe for a plenary session, but granted permission for the holding of a sectional meeting with a limited program.

Already it has been announced that thirty-two countries will be represented at Basel and seventy papers will be presented, including five from the United States. Although this country is not participating officially, the American Society of Mechanical Engineers has appointed a committee of three to represent it unofficially, and a number of American engineers will be in attendance.

While it is true that developments are comparatively rapid in the power field, two years would hardly encompass sufficient advance in practice, or changes in economic conditions, to warrant an international conference of such standing. Prompted by the Basel meeting, there are likely to be requests for subsequent meetings at short intervals, in connection with other exhibitions or like occasions. Such being the case, there is always the danger of the sessions becoming perfunctory or making the occasion one for delving into certain matters that are already being taken care of by other bodies.

It is hoped that the Basel sectional meeting will do neither, and that it will justify the highest hopes of its sponsors without taking the edge off the next regular World Power Conference.

Liberality not Always Admirable

RECENTLY, in the examination of the operating costs of some forty oil-engine plants, it was found that the two items showing the greatest divergence were the lubricating-oil consumption and the repair cost.

The fuel oil consumed per unit of output at a given load factor is practically the same regardless of the engine design. This is but natural inasmuch as the jacket and exhaust losses are not susceptible to any great change. Since the amount of rubbing surface in terms of square feet per minute per horsepower is practically constant, save in engines with unusual bore to stroke ratios, the rates of lubricating-oil consumption should be consistent.

The secret of the discrepancies lies in the type of operating engineer. He can do little to influence the fuel consumption without deranging the engine, but can and does alter the rate of lubricating-oil feed, often without justification other than that he wishes to play safe, and it is seldom that the log reveals too little lubricant used.

The disadvantage of this excessive use of lubricants is not its cost, although this mounts to an alarming figure, but is the machine's lack of reliability, which is accompanied by an increase in the maintenance cost. Contrary to the average engineer's views, the thin film of oil deposited on the cylinder walls is burnt away during the next combustion period, and to obtain proper operation the lubricant must be consumed without leaving any carbon. If an excessive layer of oil is placed on the walls, all will not burn and the remainder, subject to slow distillation, will leave a mass of carbon that in time cokes into a hard mass which scores the

piston and prevents the transfer of heat to the jacket water. As a result the safety motive prompting excess feeding actually defeats itself and the engine's performance becomes anything but acceptable.

High-Pressure Pipe Joints

STEAM pressures of four hundred pounds per square inch and over involve the use of special forms of pipe joints such as those with thin metal gaskets, narrow male and female with gaskets, ground joints or welded joints such as the well-known Sargol. All these joints have been successfully applied, yet as a class they have been subject to certain criticisms. Sometimes certain forms develop leaks with wide ranges of temperature. Gaskets can be replaced only with great difficulty. Sections of pipe or fittings can be removed or replaced only at considerable trouble and expense. Joints cannot easily be broken. First cost is often too great. Furthermore, it is difficult to develop standards for high-pressure piping while the development of joints is still in a state of flux.

These comments indicate that improved forms of joints free from these criticisms would be welcomed by power-plant designers. At the present time the tendency of power-plant engineers is to continue to use those forms of joints which are now in successful service in various high-pressure plants rather than to develop new joints for high-pressure steam.

Pressures higher than those in use in steam power plants are in commercial use both here and abroad in various chemical plants which manufacture such products as synthetic ammonia, methanol, synthetic motor fuels and certain nitrogen products. These materials at high pressures and temperatures are fully as difficult to pipe as steam. Some interesting development work in valves and piping for such services has been carried out, and some new and successful designs have been tried.

Power-plant engineers who contemplate the use of steam pressures and temperatures above those now employed, should thoroughly acquaint themselves with these developments in an allied line. It is quite possible that many of the special devices developed for chemical work may find successful application in the power plant.

Test Your Plant Every Month

IT IS good business for any production man to know what his product costs. In most manufacturing plants it is considered indispensable. Unfortunately, in many industrial power plants no effort is made to determine the cost of power.

Why not find the facts? It is easy to do, and the knowledge will be valuable. If it develops that costs are low, it will be agreeable to know it and to watch performance closely to keep them low. If, on the other hand, costs prove to be high, vigorous efforts should be directed to locating the causes and finding a remedy. Perhaps the solution will be to abandon the plant and buy power. Of course no engineer wants to figure himself out of a job, but if he be an honest man, he must advise his employer honestly and fearlessly. In many cases, however, especially where there is need for heat as such, the private plant can justify its existence if it be properly equipped to do a good job.

The first step to finding the cost of power is to find the cost of what goes into the plant—fuel, supplies and labor. These should be tabulated month by month and for even a large plant are easy to handle. Of course the coal going into the plant—not into yard storage—should be weighed and charged as it enters the boiler room. The total expense for supplies and labor should be easy to obtain from personal records of the engineer in the small plant or from the accounting department of the larger organization.

The next step is to determine the net plant output. Electric power output is easy to measure. Care should be taken to deduct any power used within the plant solely for its own internal requirements. This can be done from the records or read directly from a meter connected at the proper point. If the power goes out over a belt or rope drive or a lineshaft, measurement is not easy, although there are special ways of doing this, and in many cases the value of the information will be worth the cost. Mechanical power is often delivered in water or air under pressure, and these are easy to measure. A flow meter will record and integrate the quantity and gages and thermometers will indicate or record pressure and temperature, and the power thus delivered can be calculated. Heat delivered as such, usually in steam, is fairly easy to measure, and any heat returned in hot condensate can be credited easily.

Thus far the accounting is easy—on the one hand, total cost, on the other, net output, electrical, mechanical and thermal. In some instances it may be just as well to let the statement stand in this form, but usually it is desirable to work out unit costs per kilowatt-hour, or per horsepower-hour, or per cubic foot of ventilating air or of water or of the free-air equivalent of compressed air, or per thousand B.t.u. of heat. This is easy if the output is all of the same kind, but if energy is delivered in two or more forms, it is often hard to decide how to allocate the cost. The value of live or exhaust steam from a power plant is the subject of never-ending discussion, and the engineer and the accountant must get together and set up a method to suit their own circumstances.

Such costs should be figured monthly. Shorter periods are too sensitive to so-called starting and stopping errors. Monthly figures are dependable, but in comparing them it must be borne in mind that the efficiency of some equipment naturally varies with the season. For example, condensing turbines do best in winter, when cold water promotes good vacuum, but boilers do their worst when all the combustion air comes in at temperatures near zero. The free preheated air of summer helps the boiler.

There is no royal road to knowledge. Instruments must be bought and kept in order. Perplexing questions of allocation must be attacked and decided. Curious inconsistencies in the results must be studied, explained and corrected. But the knowledge is worth all that it costs, because it shows the way to lower costs or demonstrates that present costs are satisfactory.

It is just as important for the engineer to keep track of his fuel, supplies and labor and what he produces from them as it is for the treasurer to keep account of the dollars he spends and what they are spent for.

The Index for *Power*, Volume 63, January-June, 1926, is now ready. It will be mailed to those subscribers who have already requested that their names be carried on the permanent mailing list for current and future indexes. It will be sent to others free on application.

Practical Ideas From Practical Men

One Way To Operate a Plant, but not the Right One

The worst mess I have ever had anything to do with in a power plant was in a large paper mill some years ago. I was sent with an expert steam boiler man to find out why the boiler in the plant would not steam. After arriving on the job and sizing up the situation, we loosened up the manhole plate on one boiler that was cold, but after jarring the plate loose, it could not be tipped sufficiently for removal. Considerable prying with a short iron bar brought the plate in a position where it could be taken out, and the cause of the trouble was revealed. Over 100 pounds of grease and sediment was taken out of this boiler, and it was necessary to put over a carload of new tubes in the boilers before the plant could be started.

In looking over the electrical equipment of the plant, we found one of the 875-kva. generators with a bearing burned out. Inquiry brought out that one electrician had been discharged for using too much oil and the one who took his place seemed to go to the other extreme. The oil used was about as cheap and low grade as it was possible to obtain. Our recommendation to the management was that the best oil obtainable was the cheapest and this also applied to the men put in responsible positions in the plant. After the boilers were cleaned and repaired, the rest of the equipment fixed up, and an oil separator installed on the return lines, the plant was put in operation, in charge of a new chief engineer and electrician and has continued to operate satisfactorily ever since. G. W. KAY.

Duluth, Minn.

How a Triple-Expansion Engine Was Changed to a Compound in an Emergency

It is not difficult to make temporary repairs to keep the plant running where a good supply of materials and tools are on hand, but when one is called upon to make repairs at sea, on boats of the old freighter type where there is usually a scarcity of material and tools, it taxes the ingenuity of the engineers to the utmost. The following is a description of how a ship was brought safely to port after a breakdown involving the high-pressure engine:

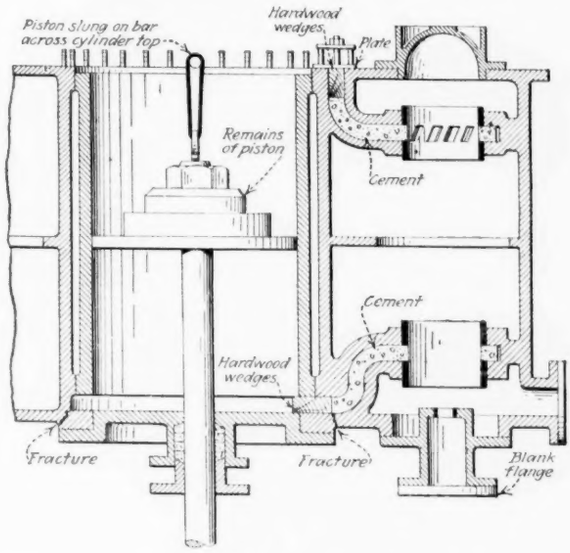
The engine was a three-cylinder triple-expansion, and while running at high speed a piece was broken out of the lower flange of the high-pressure piston, and the piston on its downward stroke forced this piece through the bottom of the cylinder containing the gland and stuffing box, tearing away the flange. The shock was such that the piston was further fractured and the pieces carried up with it on its upward stroke and forced through the top cover of the cylinder.

This accident happened off the north coast of Australia, away from the well-traveled ocean lanes, with little or no chance of assistance to be had from passing ships.

In order to get to the nearest port, therefore, something had to be done at once. It was decided to run the engine compound in the following manner:

What was left of the high-pressure cylinder cover was removed, and the piston and rod holding the bottom cover were lashed to a steel rod laid across the top of the cylinder. The connecting rod was then removed, also the eccentric rods, valve gear and piston valve.

As the steam entered the valve chest above the top of the piston valve, in order for it to get into the intermediate valve chest, it was necessary to block up the high-pressure cylinder ports. This was done in



Steam was bypassed to the intermediate cylinder by filling the ports to high-pressure cylinder with cement

the following manner: The piston was lowered to just above the bottom steam port and with the cover resting on the crosshead it was possible to work from inside the cylinder. The bottom port was first blocked up with pieces of hardwood at the cylinder end. Then a wooden plug the diameter of the piston-valve liner was driven into the bottom liner, its face being level with the bottom edge of the steam port. The port was then filled with cement well tamped in. A tight-fitting plug was finally driven into the liner so as to block the port completely. To fill the top port a similar plug was fitted temporarily into the top liner, and as the port came out on the cylinder end face, the steam passed through another port in the cover. This port was easily filled with cement from the outside and closed up with a hardwood block which was secured in place by fitting a steel plate over it and holding it down by bars and studs. The valve-rod stuffing box was closed up with a

steel plate, and the engine was ready for service again. Steam at 100 lb. was admitted and, instead of passing to the high-pressure cylinder, was bypassed to the intermediate cylinder, and thus the engine operated as a compound instead of triple expansion. A voyage of six weeks was encountered before a port was reached where a new cylinder could be obtained. During this time the engine handled easily and no leak was noticed, the cement forming a perfect bond with the ports of the valve chest.

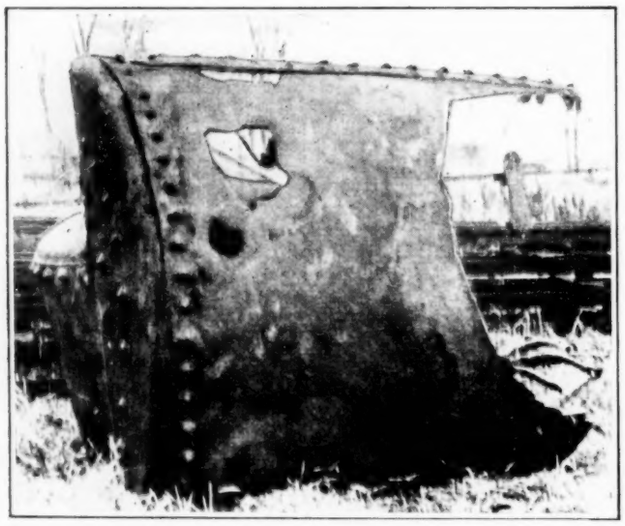
M. C. COCKSHOTT.

Hollywood, Calif.

Leaky Valve Stem and Rain Cause Serious Corrosion of Boiler Shell

A 42-in. by 11-ft. horizontal-return-tubular boiler having double lap riveted seams, built in 1914 and used in a silk manufacturing plant at a pressure ranging from 10 to 70 lb., was found by the fireman to be leaking steam through the sand covering on top of the boiler just back of the smokestack and in front of the steam dome on the first course. The fireman informed the manager of the leak and he ordered the fire drawn at once so the boiler could cool down. The next day the sand covering was removed, also part of the brick wall on the left side, so the longitudinal seam could be examined.

The manager then got a hammer and by going over the plate discovered four thin places in the boiler shell, one approximately 1½x4-in. and one 1½x6-in. along the



Section of boiler shell damaged through external corrosion

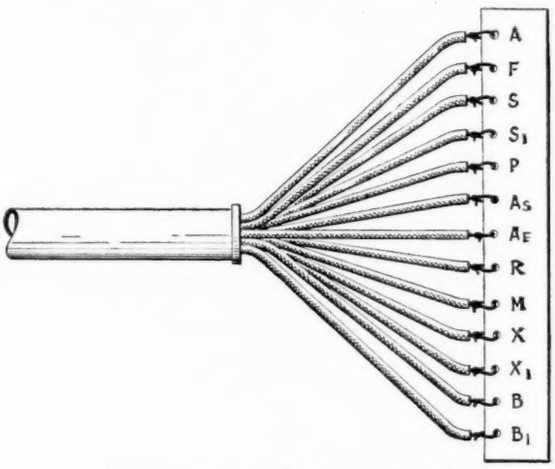
longitudinal seam, one approximately 8 in. in diameter between the seam and the top of the boiler and one approximately 3 in. in diameter nearly on top of the boiler, as shown in the illustration. In all cases the plate was corroded away almost to a paper thinness.

Along the dome seam the plate was corroded away, practically 75 per cent—but no holes were found. This condition was caused by leakage from the valve stem of the main stop valve and an opening around the smokestack through the roof, permitting rain to fall into the sand covering of the boiler, which retained the moisture and caused the outside corrosion of the boiler plates. The inside of the plates were apparently as bright as when new.

Albany, N. Y. SAMUEL A. BOWEN, Inspector, N. Y. State Labor Department.

Marking Wires After They Are Tested

Everyone who has connected up motor controllers and other equipment that have a large number of wires of the same size running to them, knows the difficulty of testing the wires out, tagging them and keeping



Wires connected to test board

them straight. The scheme shown in the figure is one that has proved very satisfactory. A piece of board is cut of a suitable length and holes bored in it to correspond to the number of wires to be tested. The holes are marked to correspond to the terminals on the apparatus to which the wires are to be connected. The man at each end of the line is given a board, and as the wires are tested they are connected in the holes, each knowing before starting which end of the board to begin connecting the wires.

When two sets of wires come to a terminal board in a pull box, two rows of holes are bored, one on each side of the board. When the wires are tested, they are connected to the board in such a way that those in holes directly opposite across the board go to the same binding post on the terminal board.

This method has a number of advantages. There are no loose wires with tags or other markings on them after the testing has been completed, and there is no danger of the tags or other markings being lost. When the wires are to be connected, if it is desired to obtain a check on the test, a man can be started connecting them up from each end of the cable, and as they disconnect a wire from the board to connect it to a terminal, they can again test it and there is no confusion as to which wire is being worked on, since both men can start working from the same end of the board. After the wires have been tested, they can be given a check test, by starting at one end of the board and testing them consecutively along the board. This can be done easily and quickly, since those making the test do not have to look for the wires. This method has been used in many cases on cables having 25 or more wires, without any trouble due to making wrong connections.

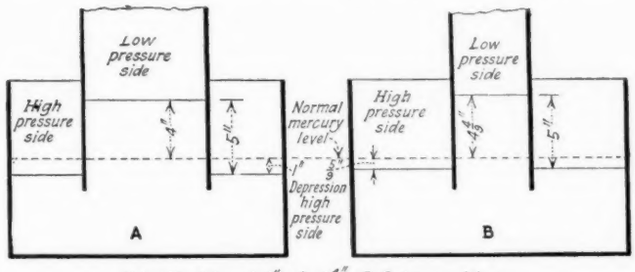
Cleveland, Ohio. H. W. SAWYER.

Comments from Readers

Troubles of a Mechanical-Type Flow Meter

The general subject of flow-meter repairs is always of interest and with proper data many useful results can be obtained. In his article on page 899 of the June 8 issue Mr. Beadle neglects to give all the facts of his case. In discussing meters, he gives a method used to overcome float difficulty. The old floats of the high-differential meters of this particular make were made concentric with the shaft, while the later ones were somewhat eccentric.

Evidently, Mr. Beadle ran into this difficulty when replacing a new internal mechanism, but his statement that it was not desired to change the sleeve in the base



Area ratio of the chambers must be considered when changing meter mechanisms

of the meter is going to get some engineer in trouble when he tries to change from, say, a No. 3 to a No. 8 internal mechanism.

Each mechanism has a corresponding sleeve which must be used for accurate results as the ratio of the high- and low-pressure areas must be considered when laying out the gearing. These various mechanisms are geared to give a full scale pen deflection for differential heads ranging from 8.11 in. of water for No. 1 to 61.4 in. of water for No. 8.

The importance of considering the area ratios of the two chambers is apparent when the sketch is considered. The ratios used are taken as a matter of convenience and are not actual figures. *A* represents an area ratio of 4 to 1, between the high- and low-pressure reservoirs, while *B* represents a ratio of 8 to 1.

In *A* every inch depression of the high-pressure side raises the low-pressure mercury level 4 in. and the total differential head would be 5 in., although the float of the meter would travel but 4 in. In *B* every inch depression would raise the low-pressure reservoir level 8 in., so that with a total pressure differential of 5 in., the high-pressure level would drop $\frac{5}{9}$ in. and the low-pressure level rise $4\frac{4}{9}$ in. and the mechanism would have to register 5 in. of head with but $4\frac{4}{9}$ in. travel.

It is apparent that if the mechanism were taken from *B* and used in *A* without changing the area ratio by using a different sleeve, the meter would read slow.

Perhaps Mr. Beadle considered this point too elementary to emphasize, but to one who has traveled around and seen some of the stunts done with these meters by various so-called engineers, the importance of emphasizing each detail would be apparent. I have found that few engineers realize the importance of considering the area ratios of the two chambers and many of those who do, do not know the reason for it.

Sometimes the area ratio of meters is made large enough so that the depression of the normal level is almost negligible except in accurate work, but one of the leading manufacturers has standardized on a 4 to 1 ratio for all meters.

F. BRIGGS.

St. Petersburg, Fla.

Caustic Embrittlement

[In view of the interest in the subject it seems well to publish the following correspondence between Professor Parr and Mr. Evans. Perhaps other readers have felt as Mr. Evans did and will welcome Professor Parr's further explanation.—Editor.]

I was much interested in the article by Professor Parr and F. G. Straub appearing in the July 29 issue of *Power* under the heading, "Illinois Experiments Support the Theory of Caustic Embrittlement." Upon studying the article carefully, however, I was unable to find what experiments supported this theory, as the only experiments mentioned were stated definitely to show that the stress must be above the yield point and that the concentration of sodium hydroxide must be in excess of 20,000 grains per gallon. Neither of these conditions are encountered in properly constructed and operated boilers, so it would appear that the experiments made tend to disprove the theory rather than to support it.

Accompanying is a copy of an analysis made by the Babcock & Wilcox Co., in 1923, of the feed water and

ANALYSIS OF SAMPLES OF WATER FROM FT. WORTH, TEXAS

(1)—Raw water from line before entering heater
(2)—No. 5 boiler alkalinity shows 1,368 grains per gallon

	(1) Gr. per Gal.	(2) Gr. per Gal.
Calcium carbonate	0.41	8.17
Magnesium hydrate	.....	Trace
Magnesium carbonate	Trace	.....
Sodium hydrate	.....	327.25
Sodium bicarbonate	40.95	.....
Sodium carbonate	.....	1,135.33
Sodium sulphate	18.85	1,150.98
Sodium chloride	7.23	427.01
Iron oxide and alumina	0.23	4.08
Silica	0.76	64.75
Organic matter	0.64	117.04
Oil	.....	1.46
Suspended matter	.....	39.55
Total solids	69.07	3,328.52
Total sodium carbonate	25.85	1,569.20

waters from one of the boilers at the Armour & Co., Fort Worth, Tex., plant. It will be noticed that the boiler-water analysis shows a large amount of sodium hydrate. These boilers had been in service twenty years at the time the sample was taken, and careful inspection

by the Hartford Steam Boiler Inspection & Insurance Co. indicated that there was no embrittlement.

As shown by the analysis, this water also contains a large amount of sodium sulphate. The map in the article indicated that, in the immediate vicinity of Fort Worth, embrittlement had occurred, and if this has taken place where sodium sulphate concentration is considerable, this evidence again would tend to throw doubt upon the whole matter. P. WILSON EVANS,

Chicago, Ill. Assistant to Supt. Motive Power, Armour & Co.

In reply to the foregoing letter, it would be my suggestion that although the abstract of the paper in *Power* is exceedingly well assembled and contains all the essential facts, the entire paper should be read, or better still, a copy of Bulletin No. 155 should be obtained from the University of Illinois Engineering Experiment Station as soon as it is published, for a fuller description of the various points. This bulletin is now in the hands of the printer and should be ready by the time this letter appears in print. To make it clear that our experiments support the theory of caustic embrittlement, allow me to quote from the article in *Power* at the bottom of page 998, first column, referring to the ratio of sodium sulphate to the total alkalinity.

> This ratio is safe since it considers all sodium carbonate as potential hydroxide, but it is misleading in the operation of certain boilers. Assuming that sodium carbonate is also an inhibitant, the ratio for actual water drawn from the boiler should be sodium sulphate plus sodium carbonate to sodium hydroxide.

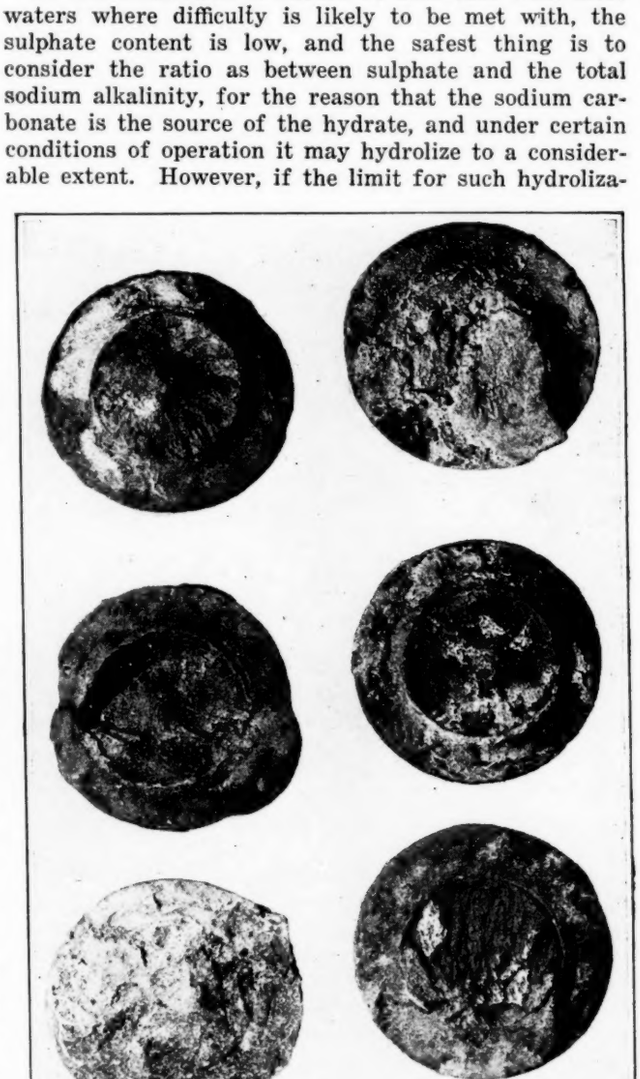
This statement is based on Table 11 of the paper read before the American Society for Testing Materials. In that table the ratio of sodium sulphate plus sodium carbonate to sodium hydroxide is the criterion which distinguishes between the boilers suffering from embrittlement and those not embrittled. This point is discussed at greater length in Bulletin No. 155.

The point is made in the foregoing letter that the concentration of sodium hydroxide must be in excess of 20,000 grains per gallon and that this condition is not encountered in properly constructed and operated boilers. The paper attempts to make clear that no boiler operates on waters of the concentration found to be essential for the producing of embrittlement, but it is evident that such concentration does occur around the rivets and between the plates, and these conditions have been reproduced in our experimental work, making it evident that a concentration may be brought about which meets the conditions found essential in the experimental studies.

We have made specific studies on the effect of the presence of sodium sulphate and sodium carbonate. Neither of these compounds causes embrittlement, and if the spaces between seams and around rivets are filled with either of these substances, no embrittling action will occur. Moreover, these constituents are much less soluble than the sodium hydroxide and crystallize out in the seams. If present in sufficiently high concentrations, they will inhibit any chemical action, so that no deleterious effect can result from the sodium hydroxide present.

With the considerations just stated in mind, it will be seen that the analysis of the water drawn from the boiler, under column 2 of the table, shows that the sodium hydrate present is 327 grains per gallon. The ratio of sulphate to hydrate, therefore, is nearly 4 to 1 and the ratio of sodium sulphate plus sodium carbonate to the hydrate is nearly 8 to 1. Under these conditions it would be impossible for embrittlement to occur.

In this connection it should be said that with most waters where difficulty is likely to be met with, the sulphate content is low, and the safest thing is to consider the ratio as between sulphate and the total sodium alkalinity, for the reason that the sodium carbonate is the source of the hydrate, and under certain conditions of operation it may hydrolize to a considerable extent. However, if the limit for such hydroliza-



These rivet heads snapped off with a light hammer blow and show white salt incrustations in the old cracks, giving evidence of high concentration in such confined spots

tion is known, there is no reason why the ratio should not be expressed as between the sulphate plus carbonate over sodium hydrate.

It would be absurd to assume that since the waters in one locality may be guilty of producing embrittlement, all waters in that same region would behave similarly. Take, for example, the explosion that occurred at Bloomington about 1910. That particular water was almost devoid of sulphates, while the city water, drawn from wells in the west part of town, had a high sulphate content, and more than this, the water supplied to the boiler that exploded has changed in character in the last five years, and now carries a safe percentage of sulphate without any additional treatment.

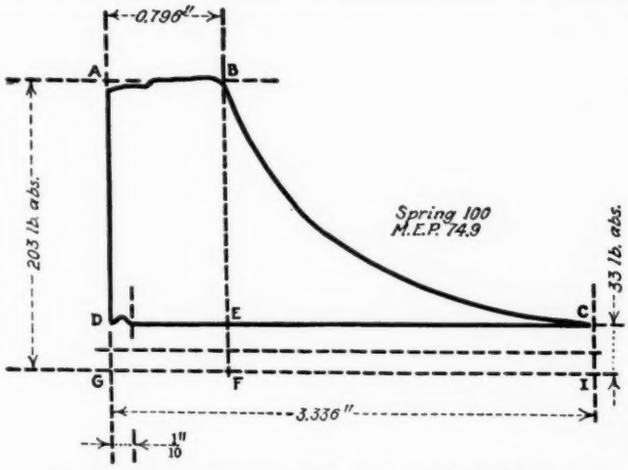
S. W. PARR, Professor of Applied Chemistry,

Urbana, Ill. University of Illinois.

Analyzing Ammonia Compressor Diagrams

The tables of the article by W. H. Motz in the May 25 issue on analyzing ammonia compressor diagrams, are very interesting and will simplify the drawing of the adiabatic curve on such diagram. I have been using the method for some time without making allowance for the superheating of the gas in the suction stroke, as Mr. Motz states he did, in preparing the tables. As it seemed too much like guesswork to try to figure out this superheating, I would appreciate a statement from Mr. Motz as to how he figured the superheating allowance.

It has always been my opinion that the adiabatic curve, drawn on the indicator diagram, was not of much value to the engineer when trying to determine the compressor operating conditions. This curve in its relation to the actual compression curve is always



Ammonia compressor diagram with division of heat added

about the same; that is, the position of the two curves does not indicate that there is anything seriously wrong with the compressor operation. When the adiabatic curve is decidedly off from the compression curve, the engineer knows there is trouble without taking an indicator diagram. The man on the job certainly needs something to give him more information as to what the compressor is doing, than what he can gain by drawing the adiabatic curve. The fact of the matter is, about all the diagram shows is the clearance re-expansion, the action of the suction and discharge valves and the horsepower; the latter is not of much value to the operating engineer.

With this idea in view I evolved the theory that the criterion by which a compressor should be judged was the ratio of the work of compression to the work of discharge of the gas from the cylinder. Since this ratio for the theoretical can be derived from the tables, and for the practical can be found from the actual diagram from the compressor, it is possible that it might be of some material value in the study of compressor operating conditions.

Consider the operating conditions shown by the diagram in the illustration: Absolute condenser pressure, 203 lb., a discharge temperature of 253 deg. F., a suction pressure of 34.25 lb., and a suction temperature of 13.5 deg.

The theoretical ratio of *BEC* to *ABED* is 0.77, calculated as follows:

Total heat of one pound of gas at 203 lb. abs. and 248 deg. F., the temperature after adiabatic compression from 33 lb. at 13.5 deg., is 733 B.t.u. The total heat at 33 lb. and 13.5 deg. is 618 B.t.u. as given by the Mollier chart. The total heat of compression is then 733 — 618 = 115 B.t.u.

As the ammonia passes through the cycle of operation, or through the system, the area *ABFG* represents the external heat of the gas. The specific volume of the gas at 203 lb. and 248 deg. is 2.106, and that of the liquid is 0.0273. The decrease in volume during condensation from *B* to *A* is 2.106 — 0.0273 = 2.078 cu.ft. The work in B.t.u. represented by the area *ABFG* becomes $2.078 \times 203 \times \frac{144}{778} = 78.04$ B.t.u.

The heat represented by *ABED* is equal to that represented by the area *ABFG* minus *DEFG*. Using the same process, we have for *DEFG*, $2.078 \times 34.25 \times \frac{144}{778}$ = 13.17 B.t.u. and the net work of *ABED* is 78.04 — 13.17 = 64.87 B.t.u.

The total heat of compression to *B* was found to be 115 B.t.u., consequently 115 — 64.87 = 50.13 B.t.u. is the heat represented by the area *BCE*. We can then write the ratio $\frac{BCE}{ABED} = \frac{50.13}{64.87} = 0.77$, this being the theoretical ratio.

Adiabatic compression to 203 lb. would give a final temperature of 253 deg. Locating the point *B* at 203 lb. and 253 deg. on the Mollier chart, the total heat is found to be 736 B.t.u. and at 33 lb. and 13.5 deg. it is 617 B.t.u. The heat of compression is then 736.1 — 617 = 119.1 B.t.u. The specific volume of the gas at 203 lb. and 253 deg. is 2.097, and that of the liquid is 0.0273, making the difference 2.07 cu.ft. We may then write

$2.07 \times 203 \times \frac{144}{778} = 77.77$ B.t.u. and $2.07 \times 33 \times \frac{144}{778} = 12.64$ B.t.u. The difference, 77.77 — 12.64, equals 65.13 B.t.u. and 119.1 — 65.13 = 53.97.

The theoretical ratio as shown by the diagram at the observed discharge pressure and temperature is $\frac{53.97}{65.13} = 0.828$.

There is then obtained the following ratios:

The theoretical ratio	= 0.77
The semi-theoretical ratio	= 0.828
The ratio by diagram areas	= 0.902

The theoretical ratio is not of much value; the semi-theoretical ratio, when compared with the diagram ratio, might be of some value if there were on record similar ratios taken from the diagrams of compressors that were known to be in the best possible condition and operating under the best known operating conditions. In other words, the operating engineer could compare the ratios taken from his compressor with those taken from a compressor of the same type and operating under best conditions.

It seems that something of this sort is needed as a guide to the man on the job, for, as I have already stated, the compression line taken alone does not reveal much about the machine's action. G. A. ROBERTSON.

Jacksonville, Fla.

Heating, Ventilating and Taking Care of Condensation in Power Plants

From an examination of a number of power plants it would seem that there is considerable room for thought relative to the heating and ventilating problems connected therewith. The condensation problem is more or less tied up with the disposition of heating and ventilating and must be considered in connection therewith.

The power plant, for the purposes of this discussion, will be divided into three parts—the boiler room, the power generation room and the control room. Each of these presents different phases.

In the boiler room the heating system depends upon the radiation losses of the equipment which, in general, is insufficient to keep the temperature at a safe point during the coldest portion of the year. Some radiation is generally found necessary, usually placed in the basement where the construction is of that type and the main floor being separated from the basement by grating which permits the heated air to rise. In single-floor boiler rooms some radiation is usually found necessary except where, perhaps, the boilers are installed in a double row facing the aisle.

Where the air for forced-draft fans is removed from the boiler room and basement, the temperature is usually so low that there is immediate danger of frozen pipes in winter. In some plants this condition is avoided by taking the air from the turbine room. However, in that case we have simply removed the danger from one place to another without correcting a fault. The practice of some designers of providing ducts with outside entrance for fresh air and connecting these ducts with the generators for cooling purposes, thereafter removing this same air through similar ducts by the forced-draft fans, seems to be a step in the right direction. In some instances a step farther has been taken and these ducts are provided with dampers by which a certain amount of air is removed from the room when found advisable. These dampers should, of course, be located in the duct between the generator and the outside wall of the room. During the summer months the volume of air may then be taken from the room and the temperature kept down to a comfortable working point. Branches may be taken off in the boiler room and the same practice applied.

If we eliminate the direct radiation generally installed near the windows of boiler rooms, there would result considerable condensation on the windows not affected materially by the usual natural-draft ventilation. Therefore, the entire problem of heating and ventilating within the boiler room may be summed up as direct radiation at the windows and natural-draft ventilation either by branch ducts from the forced-draft fans or by incorporating grating in the floor.

The elimination of condensation within the boiler room, particularly on the roof, is a matter that is engaging the attention of engineers. This problem has been solved well by the use of a layer of cork, hair felt or other insulation laid directly on the roof slab beneath the regular roofing. This insulation prevents the rapid transmission of heat through the roof and decreases the condensation. The further elimination of steam releasing items within the boiler room will stand investigation. For example, the wetting down of live coals in front of the boilers by the fireman in hand-fired plants is a nuisance, causing large clouds of steam to rise to the roof, where it condenses and falls back in large drops of water.

The turbine room, as it is generally designed, requires no auxiliary heating installation, there being sufficient heat losses from the equipment to bring the room to a comfortable temperature during the winter except in the extreme case. Here again we have the window problem, and it would seem that a thin stream of warm air released along the windows is the best solution.

The small industrial plant using perhaps a rather small reciprocating engine will find some radiation necessary. This is due to the general tendency for such engine rooms being far larger than actually necessary and the large exposed area as compared with the smallness of the unit installed. The thoughtful protection of exposed surfaces of such engine rooms would assist materially in reducing the radiation necessary. For example, the engine room made adjoining the boiler room with, perhaps a communicating door between, whereby some of the heat of the boiler room may be admitted.

The ventilation of the turbine room was previously mentioned. However, we find numerous instances where the air for the forced-draft fans is removed from the floor level of the room. It is advisable to remove the air from near the ceiling, as this will provide better working temperatures. The cooler air is down near the floor, while the hot air is near the ceiling. The dampered ducts may be run upward along the walls and the inlet provided near the ceiling. In the summer these are kept open continually, while in the winter they are partly closed and the greater volume of air taken from the outside.

Condensation is of far greater importance in the engine and turbine room. Here the dripping of condensation upon the equipment is bad indeed. The roof should be insulated in the manner given above or an insulating tile used. The roof will be slightly higher in initial cost, but it pays. The exhaust of steam from glands, auxiliaries and piping should be eliminated within the room. There is no defense for this condition.

Electric control rooms must be heated by the installation of radiation. A comfortable working temperature of, say, 65 deg. should obtain. The general tendency throughout the power plant is to install more radiation than is necessary. The radiation may be direct or indirect with a leaning to indirect due to the hazard of leaky steam pipes, water pipes and in fact the piping itself. This is of sufficient importance that it should be the determining factor where both systems of heating are not advisable in the same plant. Indirect radiation will serve as well in the turbine room and where required in the boiler room; in fact, the practice of placing an air pipe along the windows whereby a stream of warm air may be directed across the window in both the turbine and boiler room is ample auxiliary heating. Then by having the force fan of the heating system available, smoke or gases may be readily drawn from the plant in cases of emergency.

So far we have said nothing regarding offices, locker rooms, toilet, hallways, shops and storerooms. These are generally provided with natural-draft ventilation and direct radiation; however, indirect radiation may be used without dire results. When using indirect radiation, attention should be given to the source of the air. The intake should be carefully located or the air washed before being released into the plant.

Moline, Ill. C. C. HERMANN.

Questions and Answers

Too Much Cushion

What causes a dashpot plunger to rebound after it makes the drop?

The rebound is due to the presence of too much cushion, and the air, as soon as the dash comes to rest, expands and forces the plunger upward.

Power Required to Excite Transformer

Why does a transformer not consume power while its secondary is open?

A transformer does consume some power when its secondary is open. This is necessary to supply the iron losses in the transformer and also the copper losses due to the exciting current.

Dry Sheet of Boiler

What part of a horizontal tubular boiler is the dry sheet? How is it protected from damage by hot gases?

That part of a horizontal return-tubular boiler which projects beyond the front tube sheet is called the dry sheet. It is protected from the furnace gases by the placing of the boiler so that this sheet rests outside the brickwork.

Reversing the Rotation of Direct-Current Motors

How can one reverse a shunt-wound and a compound-wound direct-current motor?

A shunt motor can be reversed by crossing either the field connections or the armature connections. If the motor is of the interpole type, then the armature and interpole winding connections are crossed. A compound motor may be reversed by crossing the armature connection or by crossing the series-field and the shunt-field connections.

Evaporating with Exhaust Steam

Under what conditions can water be evaporated by exhaust steam?

Water can be evaporated by exhaust steam if, for example, the water is contained in a closed vessel and the steam introduced into a set of coils. The vapor or steam given off by the body of water must be removed at a rate such that the existing pressure in the vessel is less than that of the exhaust steam. In this way the temperature of the evaporating water is lower than that of the exhaust steam which is necessary to set up a heat flow from steam to water.

Correcting Power Factor by Installing a Synchronous Motor

Our power load is about 256 kw. at a power factor around 0.75. We are going to install a 100-hp. synchronous motor to develop about 25 hp. What will the new power factor be?

The amount that the motor will affect the power factor will depend upon the type of machine. There are two types of synchronous motors, one operating at 100 per cent power factor at full load, and the other operating at 80 per cent leading power factor at full load. If you install the 100-hp. unity factor motor, and operate it at about 25 per cent full load, it will correct the power factor to about 80 per cent. If the motor were operated at full load, the power factor of the system would be slightly higher than this. Using an 80 per cent power-factor motor will raise the power factor to around 86 per cent, if the motor is operated at 25 per cent load, and to about 90 per cent if the motor is operated at full load.

Use of a Slip Regulator

What are the functions of the slip regulator and the exciter as applied to a flywheel motor-generator set?

The function of a slip regulator when used with a flywheel motor-generator set is to cause the motor to slow down and allow the flywheel to give up part of its energy to help carry the load when load is applied, and to speed up the motor when the load is taken off, so as to store energy in the flywheel. The function of the exciter of the flywheel motor-generator set is to excite the field of the generator and the field of the direct-current motor to which the set supplies power.

Dividing Load Between Two Alternators Operating in Parallel

We have two 750-kva. 480-volt 3,600-r.p.m. 60-cycle turbo-alternators operating in parallel. We should like to know what the difference in speed would have to be in order that one turbine would take all the load. How much difference in speed would throw them out of step? If you are carrying 600 kw. on both machines and shift all on to one machine do the turbines stay at same speed during shifting?

There will be no difference in the speed of the two generators when they are operating in parallel, irrespective of the division of load between them. Both machines must operate at the same speed and frequency to stay in parallel. If there is any change in speed, both machines must change alike. When one machine is made to carry more load than the other by adjusting the governor to increase the speed, the speed of both machines increases alike, one due to governor adjustment from the switchboard, and the other due to the amount of load rejected. On the machine that has its speed increased from the switchboard, the rotor poles advance slightly in their relation to the stator poles, while on the machine on which load is rejected, the rotor poles will shift slightly backward, relative to the stator poles. This shifting of the relation between the rotor and stator poles amounts to only a few degrees, depending upon the type of machine and the amount of load change.

[Correspondents sending us inquiries, should sign their communications with full names and post-office addresses. This is necessary to guarantee the good faith of the communication and for the inquiries to receive attention.—Editor.]

A new slant on things observed in and out of the power plant

What Happens and Why?

Belt Transmission and Idler Pulleys*

THE purpose of this article is to show how an idler pulley increases the power a belt can transmit and how to determine the necessary weight of the idler pulley for various layouts. While it is necessary to use logarithms if the belt tensions are to be computed in the ordinary way, this necessity can be avoided by using the diagrams given in Figs. 1 and 2.

Like a Rope Around a Post

Everybody knows that if a rope is wrapped once or twice around a post, a small pull on one end will resist a large pull on the other. Even if the rope is only wrapped halfway around, there is still a considerable difference between the two pulls. This increases rapidly as the angle of contact (that is, the number of degrees of circumference through which the rope touches the post) is increased.

Now consider the case of a pulley that is transmitting or receiving power by means of a belt. If it is a driving pulley, the tension of the section of belt coming onto the pulley is greater than the tension in the section leaving it. Only the difference between these two tensions is effective in transmitting power. The belt, on the other hand, must be strong enough to withstand the maximum pull on the tight side which, of course, is always greater than the effective pull, or difference between the pulls on the tight and loose sides.

To transmit a given amount of power at a given belt speed takes a definite effective pull or difference in tension. For any given belt and pulley, surface conditions and arc of contact, the tension on the tight side will be a certain definite number of times the tension on the loose side, when the belt is on the point of slipping.

For example, a leather belt on a paper pulley with an arc of contact of 180 deg., or halfway around, gives a tight-side tension approximately five times that of the loose side. Suppose it is exactly five times as much. Then the effective pull will be the difference (five times the loose-side tension minus the loose-side tension), or four times the loose-side tension. So if the loose-side tension is 100 lb., the tight-side tension will be 500 lb. and the effective tension will be 500 — 100 = 400 lb. If the amount of power to be transmitted and the belt speed are such that an effective tension of 1,000 lb. is needed, then the tension on the loose side must be one-quarter of this amount, or 250 lb., so that the tension on the tight side will be 250 × 5 = 1,250 lb. This gives the desired effective tension of 1,250 — 250 = 1,000 lb. It should be noted that this "five to one" relation holds only for the particular conditions assumed.

The ratio of the tensions, as already explained, depends not only upon the co-efficient of friction between the belt and the pulley, but also upon the arc of contact.

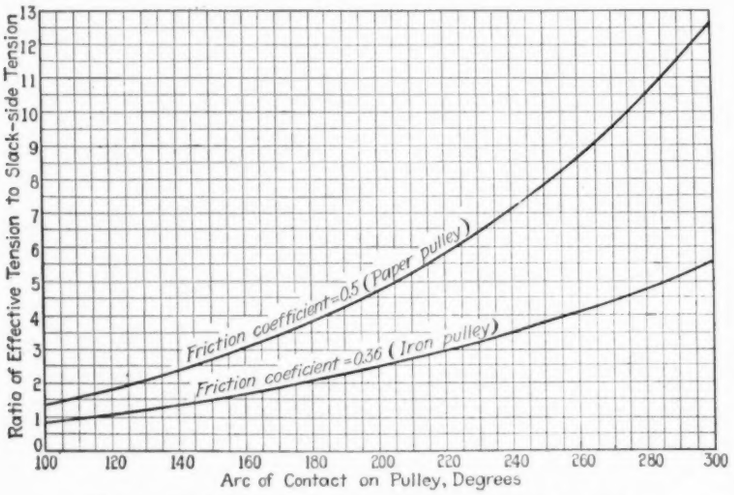

Ratio of Effective Tension to Slack-side Tension
Friction coefficient=0.5 (Paper pulley)
Friction coefficient=0.36 (Iron pulley)
Arc of Contact on Pulley, Degrees

Fig. 1—Ratio of effective tension to slack-side tension

Curves Give Needed Data

Fig. 1 gives the ratio of the effective tension to the slack-side tension for all arcs of contact from 100 deg. to 300 deg. The upper curve is for a leather belt on a paper pulley (co-efficient of friction = 0.5) while the lower is for a leather belt on an iron pulley (co-efficient of friction = 0.36). The co-efficients of 0.36 and 0.50 are conservative values for drives under fair operating conditions. Fig. 2 gives similar curves for the ratio of the tight-side tension to the effective tension.

A study of these curves will show how an idler pulley arranged to increase the arc of contact increases the power that can be transmitted by a given belt traveling at a given speed.

Assume that iron pulleys are used and that the maximum safe working tension in the belt used is 1,000 lb. Taking this as the constant tension on the tight side, the less the tension on the slack side the greater will be the effective difference and hence the greater the amount of power transmitted. With a straight drive the arc of contact will *average* about 180 deg.

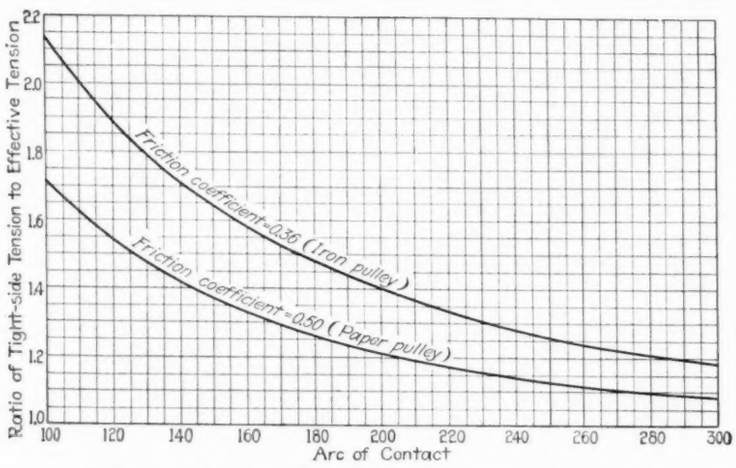

Ratio of Tight-side Tension to Effective Tension
Friction coefficient=0.36 (Iron pulley)
Friction coefficient=0.50 (Paper pulley)
Arc of Contact

Fig. 2—Ratio of tight-side tension to effective tension

*Based on material furnished by W. J. Tait.

on the two pulleys. But where the pulleys are of different sizes, the arc of contact will be less on the small pulley and this will determine the maximum power that can be transmitted.

Assume that the arc of contact is 150 deg. on the small pulley. For this condition Fig. 2 shows that the tight-side tension is 1.64 times the effective tension. So the effective tension will be 1,000 lb. ÷ 1.64 = 610 lb.

Now suppose that the use of an idler pulley on the slack section of the belt increases the arc of contact to 230 deg. on both pulleys. The idler is weighted to give the same tight-side tension of 1,000 lb. as before. The ratio of tight-side tension to effective tension will now be 1.31 and the effective tension will therefore be increased to 1,000 ÷ 1.31 = 764 lb. The power transmitted, being proportional to the effective tension, will be 764 ÷ 610 = 1.25 times as much as with the straight drive.

For a given layout of idler-pulley drive the slack-side tension (and hence the tight-side and effective tensions as well) are determined by the weight of the idler pulley, including any weights attached to it.

Problem Worked Out

The method of figuring the tensions can best be illustrated by a simple problem. Fig. 3 shows diagrammatically an idler-pulley drive laid out to scale. This drive is to transmit 50 hp. at 870 r.p.m. of the driver. The driver is a 15-in. paper pulley, while the driven pulley (of cast iron) is 45 in. in diameter. The center distance is 5 ft. An idler pulley, conveniently located on a swinging arm as shown, gives an arc of contact of 216 deg. on the driver and 256 deg. on the driven pulley.

Consider the forces acting on the idler pulley. There is first its weight acting straight down. Then each of the two sections of belt leaving the idler exerts a force equal to the slack-side tension. In addition there will be a small force acting along the idler arm.

Before the weight W can be determined, it will be necessary to figure the slack-side tension. We first figure the speed of the belt coming from the 15-in. pulley turning at 870 r.p.m. as follows:

$$\textit{Circumference of pulley} = \frac{15}{12} \times 3.1416 = 3.93 \text{ ft.}$$

$$\textit{Belt speed} = 3.93 \times 870 = 3{,}420 \text{ ft. per min.}$$

The power (50 hp.) is equivalent to 50 × 33,000 = 1,650,000 ft.-lb. per min., so the effective tension must be 1,650,000 ÷ 3,420 = 482 lb.

From Fig. 1 we see that for 216 deg. of contact and a paper pulley the effective tension is 5.6 times the slack-side tension. The corresponding ratio for the iron pulley with 256 deg. contact would be 4. Using this smaller figure, the slack-side tension is seen to be 482 ÷ 4 = 120 lb.

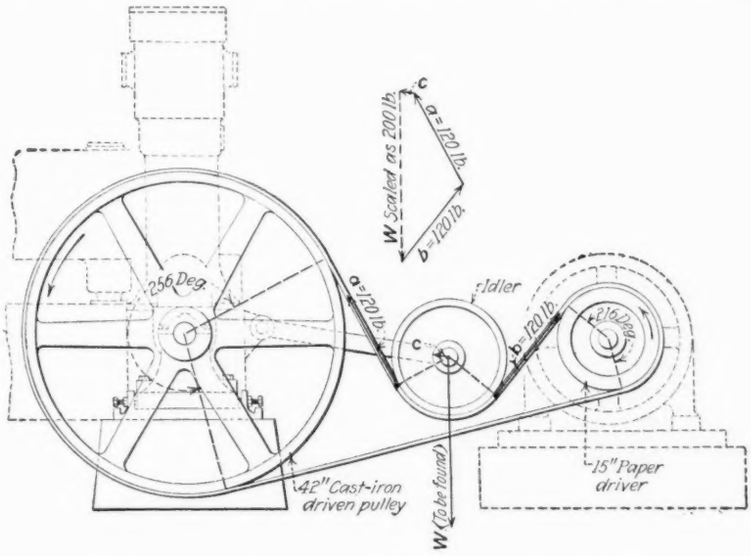


Fig. 3—For the given set-up the force polygon shows that the idler must weigh 200 lb. to produce a slack-side tension of 120 lb.

If we now lay out the separate forces acting on the idler as arrows of the proper length and direction and place them end on end with the arrows all running around in the same sense, the tip of the last arrow must fall on the beginning of the first. In the language of mechanics the polygon of forces will "close" because the idler pulley is in equilibrium under the various forces.

The directions of all the forces are known, as well as the amounts of two of them. This is sufficient data for drawing the force polygon as shown in the upper part of Fig. 3. Note that each arrow represents, both in length and direction, one of the forces acting on the idler.

After drawing b and a as shown, draw a vertical line from the bottom of b to the point where it cuts a line drawn from the arrow tip of a parallel to c. This line is W. Scaling shows it to be 200 lb., which is the required weight of the idler for the drive to deliver 50 hp. This weight need not be all in the idler itself, but the idler plus arm and extra weights must be equivalent to a 200-lb. idler.

It will be noted from the data given that the design shown would slip the belt on the iron pulley first. The design could be improved by shifting the idler to increase the arc of contact on the iron pulley even at the loss of some contact on the paper pulley.

Miscellaneous Suggestions

The idler arm should be nearly horizontal to secure the greatest advantage from the weight of the idler pulley. This weight, as already stated, may be furnished by the pulley itself or by weights attached to the supporting arms. Separate weighting gives a greater possible range of power transmitted, but may thus lead to overstressing the belt. For a constant load the pulley itself is the best weight, since it is carried directly by the belt and so imposes practically no load on its bearings.

Various devices are in use for supporting the idler pulley, and any system that allows for the adjustment of the pulley to the line of the belt will be satisfactory.

On machines difficult to start some additional weight of idler must be provided for starting. This may be done also by a rod and spring snubbing the idler arms or by weights added directly to the arms.

Comparison with other belt drives shows that even with the added weights these idler drives operate with less total tension in the belts. The operation of the belt at no greater tension than that for which it was designed, is an important factor in the upkeeping of belting and bearings.

An idler-pulley drive occupies small space, requires less initial cost of belt and lessens the upkeep on belts and machine bearings, while preserving the flexibility inherent in a belt drive.

Proper Location of Compressor Intake

The intake pipe of an air compressor should be run outside the engine room so as to admit the air at some height above the ground level, according to the Compressed Air Society's Standards. The end should be suitably hooded and provided with a wire screen and strainer to keep out dust and dirt. The strainer screen should have at least four times the area of the suction pipe, and should be so constructed as to be easily removable for cleaning, as it will become foul with rubbish to such an extent as to choke off the air supply. Piping should be the full diameter of the intake opening on the air cylinder with an increase of one inch in diameter over this size for every eight feet in length. An actual gain in delivery of one per cent is obtained for every five degrees temperature reduction of the intake air.

In many industries it is impossible to locate the intake so that clean air can be taken into the machine without some form of air cleaner or filter connected with the intake piping. Wherever dust or foreign matter is continually sucked into a machine, this causes rapid wear and forms a coating on cylinders, valves, etc., and where these conditions exist an air cleaner must be used.

New and Improved Equipment

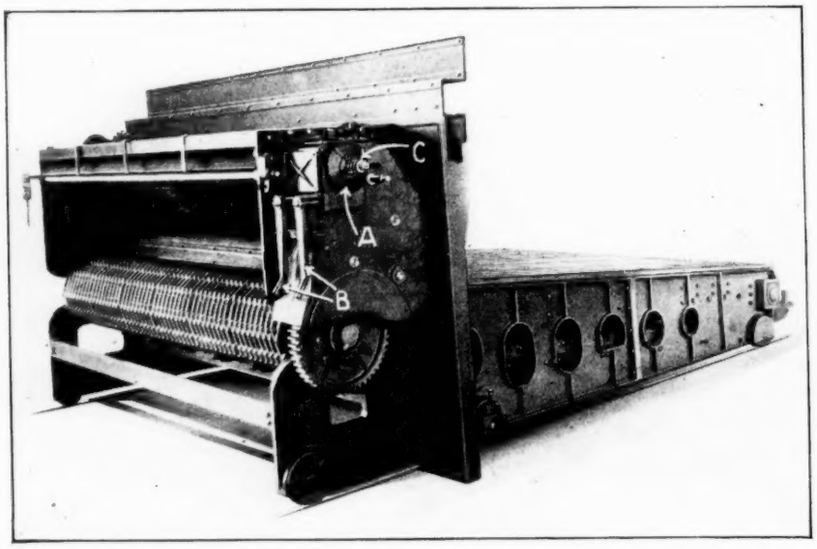


Fig. 1—Natural-draft stoker for bituminous and lignite fuels

McClave Chain-Grate Stoker for Bituminous and Lignite Fuels

In the July 27 issue the chain-grate stoker recently developed by the McClave-Brooks Co., Scranton, Pa., for anthracite and coke breeze was illustrated and described. Reference was also made to the new stoker for bituminous and lignite fuels which is illustrated herewith. As these two stokers are similar in many respects, such as arrangement of wind-box, air compartments and dampers, type of drive, etc., the reader is referred to the previous description for more complete details of these features.

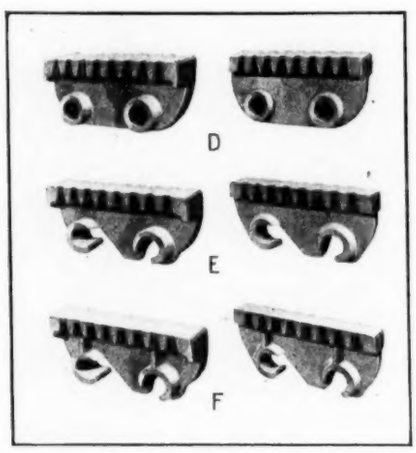


Fig. 2—Chain links for natural- and forced-draft operation

Like the anthracite stoker, the bituminous stoker is made as a combined forced- and natural-draft unit and for natural draft only. Fig. 1 shows the natural-draft stoker fitted with the three-speed spur-gear drive. The gear is driven through a chain to the sprocket *A*, and the speed change is made by the hand levers *B* on the front of the gear. The tension spring *C* provides the safety feature, and the tension can be increased or decreased to give a safe load on the stoker. The drive is carried in machined guides arranged for lateral adjustment, so that the pinion and large gear can be kept in proper mesh. The ratchet and spur gear drives are interchangeable on both the natural- and forced-draft stoker.

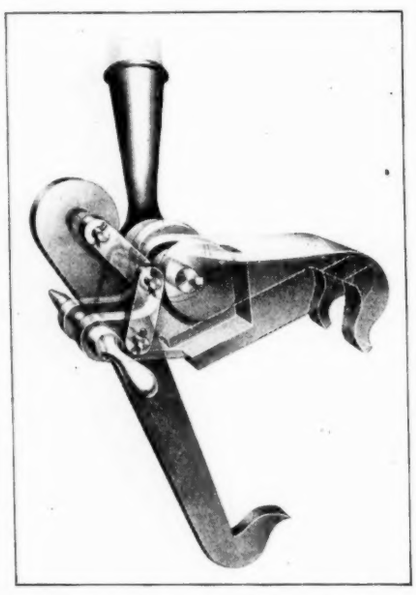


Fig. 3—Jack used for replacing broken links

The chain of the bituminous stoker is composed entirely of removable links, shown at *E* and *F*, Fig. 2, for natural- and forced-draft operation respectively, both the regular and sprocket links being of the removable type. The links *D* can be furnished when requested. For changing the links, which can be done with the stoker in operation, the jack shown in Fig. 3 has been developed. The jack is placed on the chain close to the link to be replaced, and the lever is pulled downward. This movement draws the link rods together, taking up the slack in the chain, which allows the broken link to be removed and a new one inserted without turning or removing the grate-link rods. The jack is furnished with all stokers.

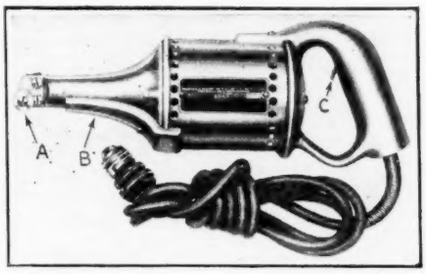
Other features of the stoker are the use of special hopper wearing backs which can be easily replaced, making it unnecessary to replace a complete hopper side should it happen to burn out or crack while the boiler is on bank; also the use of dampers at the rear end of the natural-draft stoker, to permit control of the air through the grate at this point, and prevent excessive air when operating at low ratings.

The Aurand, Jr., Commutator Slotter

To supplement the Aurand heavy-duty slotter for large commutators, which has been in service for a number of years, the Junior model shown in the accompanying illustration has been developed. This is a comparatively light portable tool, designed along the same lines as its predecessor, to be used on the smaller commutators or in plants where there is a limited amount of work to be done. It is particularly recommended for the industrial plant having a wide range of commutator sizes or as a tool to be carried in the kit of maintenance and repair men, the entire machine weighing approximately 5 pounds.

As shown in the illustration, the cutting is done by a circular saw *A* of only 1¼ in. diameter, which gives access to difficult places and permits the cut to be made right up to the radials. The saw is mounted on a mandrel carrying a worm gear connected to the motor by a steel driving shaft. This motor is of the universal series-wound type for use with either alternating or direct current. It is wound for 110, 220, 250 or 275 volts. The control for the machine is a trigger switch *C* in the handle.

In the cutting operation the saw is placed at the radials and the tool drawn toward the outer edge of the bars. A fan mounted in front of the motor and discharging through the air vent *B* shown in the foreground, keeps



Junior slotter is adaptable to a wide range of commutator sizes

the working field free of mica dust. The slotter is marketed by the Green Equipment Corp., Monadnock Block, Chicago.

Chico Wall Tile Blocks

In these days of high duty operation in the boiler plant, furnaces of comparatively large volume call for higher and thicker walls, imposing loads as high as 40 lb. per sq.in. on the firebrick. When to this are added the stresses due to lateral expansion and often the load of combustion arches and powdered-coal burners, in conjunction with high furnace temperatures, the results are such that it has been necessary for the manufacturer of firebrick to sacrifice refractoriness to obtain unusual load-bearing qualities.

To obviate this undesirable situation, the Chicago Fire Brick Co., 111 West Washington St., has developed the "Chico" wall tie blocks to divide the firebrick lining into self-supporting sections and transfer the weight to the outer bearing wall of ordinary brick. With the usual proportion of nine courses of firebrick to one of tie blocks, shown in Fig. 1, the maximum compression on any brick does not exceed 1.7 lb. per sq.in., so that there is an ample factor of safety to give a choice to any type of brick preferred.

The blocks are made in one size and shape, with tongue-and-groove keys which interlock only when the blocks are staggered and in alignment. They are of the same length, but twice the width and thickness of the standard 9-in. firebrick, so that they are equivalent in volume to four bricks. The weight of each block is 29 pounds.

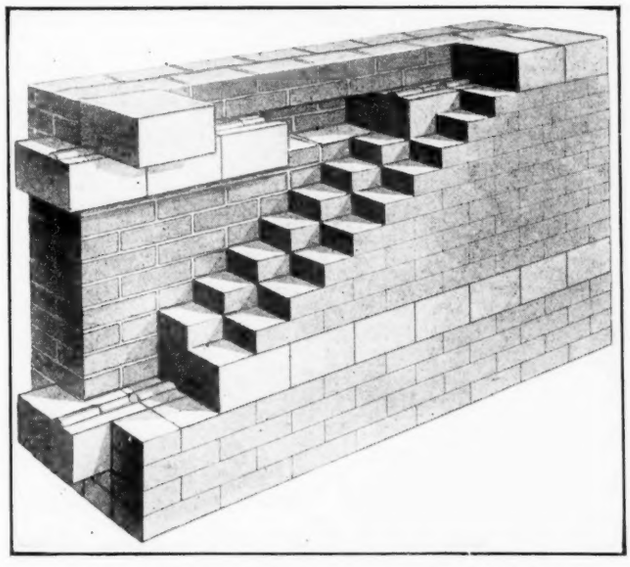


Fig. 1—Chico wall tie blocks and firebrick lining

It will be seen that every section of nine courses of brick and the attending course of tie blocks is self-supporting and independent of every other section, so that replacement at any particular location will not disturb the balance of the wall. The tie blocks extending to the fire face can be renewed as readily as the brick without disturbing the tie blocks extending into the setting wall. As the blocks carrying the load of a section are protected from the fire, they are not subjected to severe service and should remain in place indefinitely without disturbing the tie between the lining and the supporting wall of the furnace. For the latter purpose the blocks are preferable to firebrick owing to their greater rigidity and shearing value.

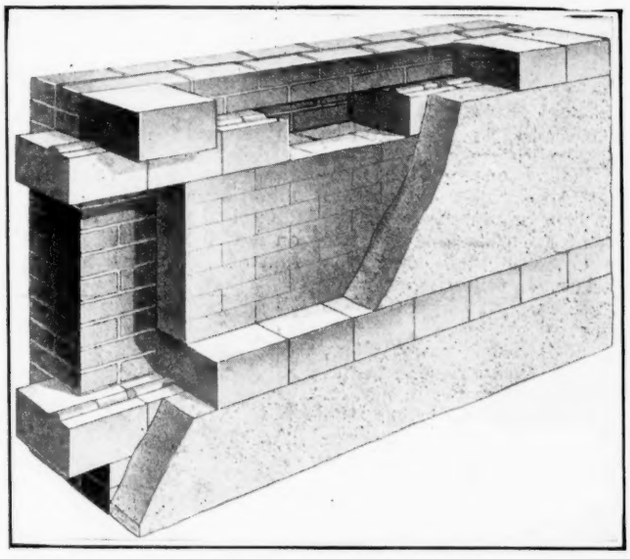


Fig. 2—Plastic firebrick lining with tie block support

Where it is desired to use plastic firebrick furnace lining, the construction shown in Fig. 2 is recommended. The tie blocks are used to divide the wall into sections, giving it greater stability and transferring the load to the common brick. As plastic refractory walls can be fired only from one side, the thickness has been limited to $4\frac{1}{2}$ in. Experience has shown that this thickness of wall can be matured without danger.

"Axiflo" Type Sump-Pump

The "Axiflo" type of pump brought out about three years ago by the Worthington Pump & Machinery Corp., 115 Broadway, New York City, and described in the June 19, 1923, issue of *Power* has recently been made adaptable to sump-pump service.

The pump consists essentially of a diving head supporting a drop pipe within which is a vertical shaft carrying one or more "Axiflo" open-type impellers and guide vanes. In operation the impellers force the water vertically through the drop pipe, thus eliminating the necessity of using the usual separate discharge pipe. As no shrouds or wearing rings are used and no close clearances are required, the pump is particularly adaptable to sump service.

On the top of the driving head is mounted a vertical motor, the thrust bearing of which carries the pump thrust load. The motor is automatically controlled by means of a float switch.

News in the Field of Power

Opening of Avon Station Made Gala Day By Cleveland Electric Illuminating

Wheels of Plant Set in Motion by C. F. Brush—70,000 kw. Capacity To Reach 300,000 kw. as Great Factor in Ohio Development—Boilers Fired by Pulverized Coal

CONSTITUTING one of the most important industrial developments in the history of northern Ohio, the Avon station of the Cleveland Electric Illuminating Co. went into operation Wednesday, Aug. 4, following the announcement made July 29 by President Robert Lindsay.

Wheels of the immense power plant, representing with accessories an initial cost of $15,000,000, were set in motion by Charles F. Brush, of Cleveland, the inventor of the Brush electric arc lamp. The initial capacity of the plant is 70,000 kw. The ultimate capacity will be 300,000 kw., and the cost will reach $30,000,000.

Augurs Rapid Development

For the opening of the power plant President Lindsay invited a representative group, including members of the industrial development committee, representatives of the public utilities committee of the Cleveland Chamber of Commerce, the public utilities committee of the Cleveland City Council, and many educators, engineers, newspaper men, and others. Prominent among industrial leaders present was Alexander Dow, president of the Detroit Edison Co.

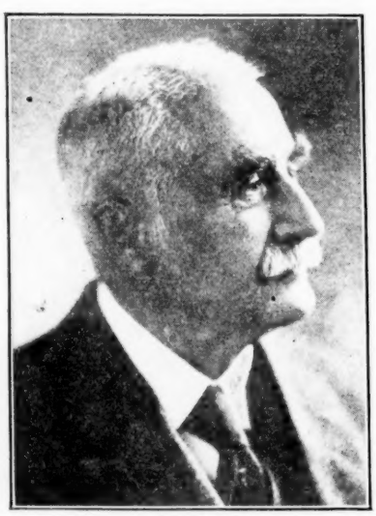
"This occasion," said President Lindsay, "marks the inauguration of one of the latest developments in electrical generation on a large scale. The plant represents the most advanced engineering practice in the production of electricity by coal and steam. In its design, both as a unit and as a factor in the Illuminating system, it has been planned to insure the highest possible standard of electrical service throughout the territory we serve."

Rôle of Brush Electric Co.

Mr. Brush said the establishment of this plant augured well for the industrial, commercial and social development of the Greater Cleveland district.

Forty-eight years ago Mr. Brush produced his arc lamp, thus making electric illumination possible. Although 77 years of age, he is still active in both business and science. In 1880 he formed the Brush Electric Co. and established a plant in Cleveland, to manufacture the arc lamp and other of his electrical inventions. Following a demonstration of the arc lighting on Public Square, Cleveland was the first municipality to adopt it for street lighting. Mr. Brush also constructed the first electric motor to be used to drive street cars, this, too, being employed in Cleveland. In 1892 the Brush Electric Co. was absorbed by the present Cleveland Electric Illuminating Co.

Ground was broken for Avon station on March 16, 1925. Its initial installation of 70,000 kw. has been rushed to completion because of the rapid increase in the demand for electricity in Greater Cleveland and contiguous territory. In the twelve months ending June 30, this year, this system generated more than 1,055,000,000 kw.-hr., or nearly twice what it produced in 1918 and nearly 200,000,000 more than it produced in 1924.

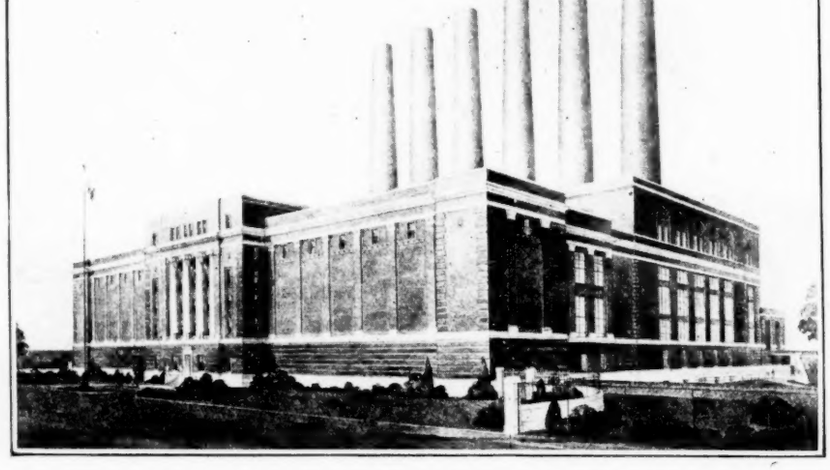


Charles F. Brush

Becoming a most important factor in the industrial development which the company has projected for Cuyahoga, Lake, Geauga and Ashtabula counties, Avon station in the past year has extended its distribution system from Avon to Conneaut, adding many thousands of consumers and affording industries in these counties the lowest industrial power rates in Ohio. The station is interconnected with Lake Shore station by a 132,000-volt steel tower transmission line, more than 30 miles in length, which surrounds the central and west part of Greater Cleveland with a belt line of power. Tying these two plants together gives assurance of uninterrupted electrical service. Avon station and its auxiliary equipment cover approximately 28 acres. The site is about 23 miles west of the Public Square and five miles east of Lorain.

Some of the Equipment

The steam-electric plant proper includes, from north to south, a coal hopper or receiving house, a coal preparation house, a boiler room to house 12 pulverized-fuel boilers, a turbine room to accommodate six turbo generators, a switchhouse and offices. The south wall of the switchhouse is 50 ft. north of Lake Road. The boilers at Avon are similar to those in the latest unit of Lake Shore station. Each pair is surmounted by a stack rising 175 ft. above the roof of the station, or 305 ft. above the lake level. Each stack is 27 ft. in diameter at the bottom and 18 ft. 8 in. in diameter at the top.



Interconnected with Lake Shore station, Avon station is situated 23 miles west of the Public Square, Cleveland, and 5 miles east of Lorain. Its appearance is as handsome as its equipment is unusually simple and workable

The furnaces will superheat the steam to 725 deg., developing a steam pressure at the boilers of 400 lb. to the square inch. Each boiler will have 30,600 sq.ft. of heating surface and will be capable of operation at three times normal rating.

The initial installation consists of four boilers and two turbo-generators, each of which is rated at 35,000 kw.

The initial building, which is two-thirds of the ultimate size of the plant, has space for four turbine units and eight boilers. Future units may be larger. Some idea of the size of the ultimate structure is suggested by the fact that 11,000,000 lb. of steel will be required for its framework.

An adequate supply of coal for the station has been assured by the provision for storage facilities for more than 100,000 tons of coal and by railroad connections with the New York Central, Nickel Plate and Wheeling & Lake Erie lines, via the Illuminating company's own railroad. The station will pump water at the rate of 420,000 gal. per min. The intake tunnel is 309 ft. long. The overflow tunnel for returning the water to the lake extends the length of the turbine-house floor, thence to the lake outlet. Its internal dimensions are 15 ft. 3 in. high and 14 ft. wide.

Third Large Plant of Company

Near the eastern end of the property is the transformer substation for stepping up the current delivered by the plant from 11,000 volts to 132,000 volts for the high-tension system.

Avon station is the third large power plant to be built by the Cleveland Electric Illuminating Co., all of the three having been constructed under the direction of President Lindsay.

The first was the Canal Road station, which is still in operation as an electric generating and steam-heating plant. The second is Lake Shore station at East 70th St. and Lake Erie, one of the largest steam-electric plants under one roof, with a capacity of 384,000 hp.

When Avon is extended to its ultimate capacity of 400,000 hp., it will give the Illuminating system more than 800,000 hp. generating facilities.

Tennessee and Alaska Apply for Development Permits

The Tennessee Eastern Electric Co. has applied to the Federal Power Commission for a preliminary permit covering the construction of three dams on the Nolichucky River in Tennessee. One of the proposed dams is to be seventy feet high. It is to be twelve miles down stream from the company's present dam. Another dam, also seventy feet in height, is to be located at Buckingham Ford. The third dam is to be ninety feet high and will be located at Embreville. It is planned to install 70,000 hp.

The Home Power Co., of Skagway, Alaska, has applied for license covering a proposed project in the Tongass National Forest.

The Sunny Point Packing Co., of Seattle, has applied for a license for a small power development near its cannery on Gunnock Creek, Kupreauoff Island, Alaska.

Canadian and N. Y. Engineers Confer on St. Lawrence

What was probably the last conference between Canadian officials and representatives of the New York State Water Power Commission, unless and until the State body takes definite action on the application for permits for St. Lawrence River power development, was held at Toronto last week.

Present at the conference, the third meeting which has been held, were Roy G. Finch, state engineer, John Newton, assistant state engineer, Deputy Attorney General Randall J. Le Boeuf, representing Attorney General Ottinger and Friend P. Williams, secretary of the New York State Water Power Commission. Representing the Canadian government were Premier Ferguson of Ontario, C. A. Magrath, chairman and F. A. Gavy, chief engineer of the Hydro-Electric Commission of the Province of Ontario.

Canadians Favor Single Stage

"The last conference," said Mr. Le Boeuf, "was to consider primarily the engineering problems involved. The Canadian officials seem to have reached the conclusion that from the standpoint of the amount of current produced the single stage development would be better, but there are both political and sentimental problems to be taken care of. The Canadian people are very much averse to taking private property for public use," Mr. Le Boeuf declared.

The next step in the power development program will be for the New York State Water Power Commission to meet and formally declare the value of a development of the St. Lawrence River water power, if it decides to issue a license, make a declaration that such development is for the public benefit and state under what terms and conditions it will issue a license.

At the present time the State Engineer and members of the commission are engaged in making a study of the Canadian plans as well as those submitted by the applicants for permits.

Engineering Policy Problem

The terms and conditions under which the New York State Water Power Commission will issue a permit do not enter into the conference between the officials of the two governments, accordnig to Mr. Le Boeuf. The conference is to decide upon the proper engineering policy.

On the Canadian side the development may be had under state ownership, while on the American side it may be brought about by private capital, but what must be determined is that the location of the dam or dams is acceptable to the Canadian people.

The single stage development would flood approximately 36,000 acres, while the two stage development would inundate about 6,000 acres. However, with the two stage development, the majority of the lands flooded would be on the Canadian side.

If the New York State Water Power Commission decides to issue a license to either of the applicants, a further conference with the Canadian officials will probably be necessary.

A. H. Horton Lays Fuel Waste to "Average Efficiency"

Public utility power plants in the United States consumed about 40,000,000 tons of coal, 10,000,000 bbl. of oil, and 46,000,000,000 cu.ft. of gas in generating electricity for public use in 1925, according to figures prepared by A. H. Horton, chief of the Power Resources Division of the Geological Survey, Department of the Interior. Commenting on these findings, Mr. Horton said:

"The average rates of consumption of these fuels is 2.1 lb. of coal per kilowatt-hour, one barrel of oil per 200 kw.-hr., and 25 cu.ft. of gas per kilowatt-hour. At the present time these rates of fuel consumption are about twice those of the best plants burning these three different kinds of fuel.

"If all public-utility power plants were utilizing fuel as efficiently as the best plants now are, the conservation of coal and the coal equivalent of oil and gas would amount to about 25,000,000 tons. The conservation of this amount of fuel would reduce the cost of fuel to public-utility companies by about $100,000,000.

Water Plants More Efficient

"The average efficiency of fuel-burning public-utility power plants is about 12½ per cent. The efficiency of a water-power plant is about 70 per cent.

"On the basis of utilization of the energy in coal and falling water, water-power plants are about 5.5 times as efficient as the average steam public-utility power plant. Even with this apparent advantage, the total cost of producing one kilowatt-hour of electricity at a hydro-electric plant is about as much or more than at a steam plant and the increasing efficiency in utilization of fuel in public utility power plants is making it more and more difficult for hydro-electric power to compete with power produced by the use of fuel."

Mohawk Merger Approved by N. Y. Commission

The New York Public Service Commission on July 29 granted permission to the Mohawk-Hudson Power Corp. to acquire all or more than 10 per cent of the common and preferred stock of the Syracuse Lighting Co., Inc.; the Seneca River Co. and the Mexican Electric Co., all serving communities in Onondaga and Oswego Counties. The three companies represent a value of $7,221,000.

At the last hearing of the commission Fred P. Corey of the Niagara, Lockport & Ontario Power Co. of Buffalo, asked for an adjournment to give his company time to study the matter. Mr. Corey explained that the merger plan contemplated the formation of a financing corporation by the Mohawk-Hudson concern to be known as the Syracuse Securities Corp., and the taking over of the Syracuse Lighting Co., valued at $4,834,600.

At this hearing Mr. Carey did not appear, but he reported that questions of interest to his company had been satisfactorily disposed of.

Duquesne Light Acquires Oliver Power Plant

Acquisition by the Duquesne Light Co. of Pittsburgh of the extensive electric power and steam heating service of the Central Power Plant of the estate of Henry W. Olive, embracing an important area of the downtown section of the city, was consummated July 28.

Described as probably the largest single transaction involving steam heating service closed in Pittsburgh and as one of the most important ever concluded by local utility companies, the merger represents a substantial addition to the service of the Duquesne Light Co. and the Allegheny County Steam Heating Co.

While the principals to the transaction declined to state the actual consideration in the transfer, the outlay of the Duquesne Light Co. in the transaction was estimated at approximately $2,500,000 in the taking over of the service of the Central Power Plant, the extensions of power and steam lines and the erection of additional substation capacity for the increased service.

The merger becomes effective Sept. 1, when the Duquesne Light Co. and Allegheny County Steam Heating Co. will take over the plant located in the Kaufmann & Baer Building at Smithfield St. and Strawberry Way. This plant will be continued in operation pending extensions to the downtown Cecil plant, after which it will be dismantled. The dismantling under the agreement must be completed June 1, 1927.

American Welding Society Plans Fall Meeting

The fall meeting of the American Welding Society will be held in Buffalo on Nov. 17, 18 and 19. An international welding and cutting exposition, held in connection with this convention will open Tuesday afternoon, Nov. 16.

Technical sessions include considerations of railroad, welding apparatus, welding science in the engineering curriculum of universities, and welding in a gaseous atmosphere. The entertainment embraces a trip to Niagara Falls, a view of the Falls from the American side, with an inspection trip through the Niagara Falls Power House, a buffet supper on the Canadian side and a special illumination of the Falls. There will be the usual annual fall banquet, which is expected to be an outstanding success, and a meeting of the American Bureau of Welding, the Board of Directors and the Welding Wire Specifications Committee.

Texas Power Companies Sued for $28,000

Charging infringement of patent rights involving reinforced concrete dam construction, alleging loss of large royalties and claiming $25,000 damages, the Ambursen Construction Co. of New York, filed suit in Federal Court, July 28, against the Syndicate Power Co. of Texas. The suit asks an injunction restraining the use of a dam constructed at Marble Falls, Burnet County. This suit followed one filed by the Ambursen company against the Citizens' Electric Light & Power Co. of Texas for $3,000 damages and alleging patent infringement by the defendant, which operates a hydro-electric plant on the Guadelupe River at Gonzales.

C. A. Coffin's Life Extolled by G. E. Board

In tribute to the memory of Charles A. Coffin, the board of directors of the General Electric Co. passed, at the first meeting following Mr. Coffin's death, the following resolution:

"Charles Albert Coffin was the founder of the General Electric Co. and throughout his life its leader. His spirit was its inspiration. He had unfaltering courage in trying times. He had modesty and self-restraint in the days of great success. He developed an art and built an industry so that his company might succeed and his country prosper. No man could do this without force and tact and sympathy. No man could do it without the capacity to select and the personality to stimulate other men. No man could do it without that modesty in his own achievements which represents the highest generosity to his associates.

"Truly, if an organization may be a monument to a man, then this company is a monument to him. Some of the members of this board have been associated with Mr. Coffin throughout the life of the organization, and others are indebted to him for their opportunity. For themselves and for every member of the organization, in whatever capacity, they record their gratitude, their appreciation of his service, and their sorrow."

Cincinnati Street Lines— "Cheaper to Buy"

Abandonment of its only remaining power plant and the purchase of electrical current from the Union Gas & Electric Co. for the operation of its street cars, is a proposal submitted to the directors of the Cincinnati Street Railway Co., it was learned recently. The power plant in question is on Eastern Avenue and for years has been known as the Pendleton Station.

The question of its abandonment has been considered by the company since it assumed control of the properties.

Officials of the Street Railway Co. contend that the company can buy power for the lines served by this station cheaper from the Union Gas & Electric Co. than the plant can produce the current.

General Electric to Supply Shoals Transformers

A contract for twelve water-cooled 21,666-kva. transformers, to convert electricity at 11,500 volts to 110,000 or 154,000 volts with the necessary high-tension oil circuit breakers, lightning arresters and substation equipment for use at Muscle Shoals, has been awarded to the General Electric Co., by the Corps of Engineers, United States Army. The bid of that company was $799,000.

More Power to Foshay— Three More Concerns

Sale of the Alturas Light & Power Co., the Fort Bragg Light & Power Co., and the Mendocino Light & Power Co. to the W. B. Foshay Co. of Minneapolis was announced July 29.

The properties which serve electricity to the cities and towns of Fort Bragg, Mendocino, Alturas, Caspar, Little River, Albion and Cedarville, changed hands August 1, and will be consolidated into a California corporation, which in turn will be controlled by the People's Light & Power Corp., owned by the Foshay interests.

Electric Company Formed for South Manchuria

The South Manchurian Electric Co., with a capital of $16,500,000, was incorporated recently in Tokyo, states a report to the Department of Commerce from Vice-Consul A. I. Ward at Mukden, China. This company has taken over the electrical works department of the Manchurian Railway Co. in pursuance of the policy of decentralization decided upon by the railway company, which is reported to have grown to such large proportions as to become somewhat unwieldly.

Plans Increased System For Middle West

A new superpower system is being created in the Middle West by the Interstate Power Co., one of the principal operating subsidiaries of Utilities Power & Light Corp. Construction plans include extensive additions to power plants in all parts of the territory served, building of high-tension transmission lines and new substations in many sections. A substantial part of the program already has been carried out, including installation of a new 10,000-kw. turbine at the company's power plant at Dubuque, Iowa.

Central Stations Sales Managers Meet

Attended by representatives from New York, the Boroughs of Brooklyn and Queens, Cleveland, Pittsburgh, Philadelphia, Buffalo and Boston, the fifteenth annual convention of the Sales Managers Association of the Central Station Companies was held at Association Island, Henderson Harbor, N. Y., on August 2, 3 and 4.

A wide variety of papers covering every phase of the commercial problems confronting the electrical industry today was presented by the delegates at the morning and evening sessions of the convention which, under the chairmanship of G. E. Miller, sales manager of the Cleveland Electric Illuminating Co., proved to be one of the most interesting gatherings held in the central station industry this year.

Charles A. Barton, general sales manager of the New York and Queens Electric Light & Power Co., was appointed chairman of the Sales Managers Association for the new year, it was announced.

Obituary

Theodor P. Kimman, works manager of the Cleveland plant of the Chicago Pneumatic Tool Co., died at his home July 24, from heart disease. Mr. Kimman was the inventor of the first four-piston air drill and was considered an authority on mechanics. He was associated with Edward N. Hurley, chairman of the United States Shipping Board, in the development of air drills.

Mr. Kimman was superintendent of the Cleveland plant from 1903 to 1921, when he succeeded his brother, H. J. Kimman, as works manager. During the war the plant was engaged in manufacturing shells for the United States, Great Britain and Russia.

Personal Mention

George L. Bascome, formerly consulting engineer at Scranton, Pa., has joined the National Valve & Manufacturing Co., Pittsburgh, Pa., in a similar capacity.

Proctor L. Dougherty, an electrical engineer, has been named by President Coolidge as a commissioner for the District of Columbia. Executive authority in the District is vested in three commissioners.

F. W. Andrew, at one time chief engineer for the Eismann Magneto Corp., Brooklyn, N. Y., is now holding a like position with the Mitchell Specialty Co., at Homesburg, Pa.

John B. Gough, previously chief engineer for the Newfoundland Power & Paper Co., Ltd., at Cornerbrook, Newfoundland, is now designing engineer for Price & Co., Ltd., Quebec.

Frederic C. Evans, assistant professor of power engineering, Sibley School of Mechanical Engineering at Cornell University, is spending a portion of his vacation period on the editorial staff of *Power*.

Anson W. Burchard, chairman of the board of directors of the International General Electric Co. and vice-chairman of the General Electric Co., recently received the degree of Doctor of Laws from Union College.

Ernest L. Blair, formerly with Lockwood, Greene & Co., Inc., as mechanical engineer in the steam department, has joined the Stone & Webster organization in its Boston office, as building service engineer in the structural division.

Harris E. Dexter, of New York, formerly engineer with the General Electric Co. has been appointed chief of the electrical equipment division of the Department of Commerce. He succeeds R. A. Lundquist, who resigned recently to enter private employ.

Lewis H. Dietz, for ten years with the Welworth Co., has become associated with Grant Campbell, consulting engineer at Short Hills, N. J., in the commercial development of steam-flow control and fluid-regulating devices.

J. G. Pertsch, professor of electrical engineering at Cornell University, is associated during the summer with the General Electric Co., Schenectady, N. Y.

K. E. Van Kuran, one of the most popular men in the electrical industry in southern California and for the past twelve years district manager for the Westnighouse Electric & Manufacturing Co. in Los Angeles, has resigned.

Business Notes

The T. G. Egan Refractory Engineering Co., Inc., announces the removal of its offices to the Temple Bar Annex, 186 Remsen St., Brooklyn, N. Y.

Henry L. Doherty & Co., fiscal agents, announce the removal of its Cleveland office from 737 Guardian Bldg. to 1400 Hanna Bldg., Euclid Avenue at Fourteenth Street.

Coming Conventions

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Regional meeting at Richmond, Va., Sept. 27-30.

Association of Edison Illuminating Companies. Chateau Frontenac, Quebec, Sept. 27-Oct. 1. P. S. Millar, 80th St. and East End Ave., New York.

Empire State Gas and Electric Association. Lake Placid Club, N. Y., Sept. 30-Oct. 1. C. H. B. Chapin, Grand Central Terminal, New York.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. Convention at Atlantic City, begins Sept. 14. Erroneously announced as Sept. 6-11. Annual conventions and exhibitions of state associations are scheduled for the following dates: **New York State Association,** Wilmer T. Meinzer, 3626-215 Place, Bayside, Long Island, N. Y. Postponed from June 11 to 12, at Troy, N. Y., to Sept. 12-13 at Atlantic City, N. J. **New Jersey State Association,** S. G. Dalrymple, 111 Hutton St., Jersey City, Convention at Atlantic City, Sept. 12; **Pennsylvania State Association,** Frank J. McCarron, 3647 North 11th St., Philadelphia, Convention at Philadelphia, Sept. 12-13.

The De Laval Steam Turbine Co. has engaged Raymond E. Roche, who for several years has been on the steam-turbine sales staff of the Elliot Co., as sales engineer with headquarters at Chicago.

The Standard Turbine Corp., Scio, N. Y., announces the appointment of C. R. Gould as its general manager. Mr. Gould has been identified with turbine manufacture for the past twenty years, most recently with the Kerr Turbine Co., for which firm he served in various capacities.

The Reading Iron Co. has appointed Robert I. Fretz, for the past year in charge of boiler-tube sales, district sales manager of pipe sales in the territory known as the Reading district, which embraces New York State, excluding New York City, and eastern Pennsylvania, excluding Philadelphia.

The Pennsylvania Pump & Compressor Co., Easton, Pa., announces the appointment of Samuel Arnold, 3d, Fulton Bldg., Pittsburgh, Pa., as their representative in the Pittsburgh district.

The Burke Electric Co., Erie, Pa., manufacturer of alternating- and direct-current motors, synchronous motors, generators, motor-generator sets, electric arc welding equipments and Universal motors, announces the appointment of R. J. Paul, 3115 Washington Blvd., St. Louis, Mo., and the W. C. Fletcher Co., 725 Continental Bank Bldg., Indianapolis, Ind., as district sales agents in their respective territories.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	Aug. 2 1926
Pool 1	New York	$2.40@$2.75
Smokeless	Boston	1.92
Clearfield	Boston	1.65@ 1.90
Somerset	Boston	1.90@ 2.25
Kanawha	Columbus	1.50@ 1.75
Hocking	Columbus	1.40@ 1.75
Pittsburgh	Pittsburgh	1.60@ 1.90
Pittsburgh gas slack	Pittsburgh	1.20@ 1.30
Franklin, Ill.	Chicago	2.25@ 2.50
Central, Ill.	Chicago	2.00@ 2.25
Ind. 4th Vein	Chicago	2.10@ 2.25
West Ky.	Louisville	1.00@ 1.40
S. E. Ky.	Louisville	1.40@ 1.75
Big Seam	Birmingham	1.75@ 2.00
Anthracite Gross Tons		
Buckwheat No. 1	New York	1.65@ 3.50
Buckwheat No. 1	Philadelphia	1.85@ 2.75
Birdseye	New York	.75@ 2.00

FUEL OIL

New York—Aug. 5, light oil, tank-car lots; 28@34 deg. Baumé, 6c. per gal.; 36@40 deg., 6⅜c. per gal. f.o.b. Bayonne, N. J.

St. Louis—July 27, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2.00 per bbl.; 26@28 deg., $2.05 per bbl.; 28@30 deg., $2.10 per bbl.; 30@32 deg., $2.15 per bbl.; 32@36 deg., gas oil, 5.8c. per gal.; 36@38 deg., 6.5 per gal.

Pittsburgh—July 28, f.o.b. local refinery; 30@34 deg., fuel oil, 5¾c. per gal.; 36@40 deg., fuel oil 6½c. per gal.

Dallas—July 31, f.o.b. local refinery 26@30 deg., $1.75 per bbl.

Philadelphia—Aug. 1, 27@30 deg., $2.62½@$2.68½ per bbl.; 18@22 deg., $1.93@$1.99; 13@19 deg., $1.70@$1.76 per bbl.

Cincinnati—Aug. 2, tank-car lots f.o.b. local refinery, 24@26 deg., Baumé, 6½c. per gal.; 26@30 deg., 6⅝c. per gal.; 30@32 deg., 7c. per gal.

Chicago—Aug. 2, tank-car lots f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.30 per bbl.; 26@30 deg., $1.35@$1.40; 30@32 deg., $1.55

Boston—Aug. 2, tank-car lots, f.o.b. 12@14 deg. Baumé 4½c. per gal.; 28@32 deg., 6c. per gal.

New Plant Construction

Calif., Long Beach—Home Ice Co., Anaheim Rd., is having plans prepared for the construction of 5 story cold storage plant, on Anaheim Rd. P. J. Duncan, Pacific Natl. Bank Bldg., Los Angeles, is engineer.

Calif., Oakland—B. Bercovich, c/o H. C. Baumann, 251 Kearny St., San Francisco, Archt., is having plans prepared for the construction of 16 story apartment, on Grand Ave. Estimated cost $1,500,000.

Calif., Watsonville—Watsonville Ice and Cold Storage Co., awarded contract for the construction of ice and cold storage plant to H. E. Heller & Co., Stockton. Estimated cost $150,000.

Fla., Fort Lauderdale—Mayor and Bd. Comrs. will receive bids until August 12, for the construction of sewage treatment plant, including power plant, equipment, etc. Soloman, Norcross & Keis, Ft. Lauderdale, and 1404 Chandler Bldg., Atlanta, Ga., are consulting engineers.

Ill., Chicago—A. C. Mather, 324 North Michigan Ave., awarded contract for the construction of 25 story, office building at 345-51 Wacker Drive, to W. A. Illsley, 53 West Jackson Blvd. Estimated cost $3,000,000.

Ill., Chicago—Sanitary District of Chicago, 910 South Michigan Ave., is having plans prepared for the construction of a service building, including heating plant, at North Side Plant, Howard St. Estimated cost $750,000. E. J. Kelly, 910 South Michigan Ave., is engineer.

Ill., Chicago — A. Story, 1544 Glenlake Ave., representing B. F. Weber, 160 North La Salle St., is receiving bids for the construction of 3 story apartment and stores building on North Clark St. between Granville and Thome Aves. Estimated cost $1,500,000. R. C. Ostergren, 155 North Clark St., is architect.

Ill., Danville—Interstate Water Co., H. Ely, Mgr., is having plans prepared boiler and water plant, here. Mead & Seastone, Journal Bldg., Madison, Wis., are engineers.

Ill., Highland — City Clerk will receive bids until August 20, for power plant equipment, including two 375 kva. noncondensing poppet valve uniflow engines, with 3 phase, 2,300 v. generators and exciters, direct connected, installed on city foundations or one 750 kva. condensing uniflow unit complete; alternate, two 375 kva. steam turbo condensing units complete as above or one 750 kva. steam turbo unit, all with piping and connections, complete. W. A. Fuller Co., 1917 Railway Exchange Bldg., St. Louis, Mo., is engineer.

Ill., Troy—City awarded contract for the construction of complete waterworks system, with pumping equipment, etc., to J. M. Monie, Chemical Bldg., St. Loius, Mo. $90,000.

Ill., Waukegan — E. P. Steinberg, 360 North Michigan Ave., Chicago, Archt., soon awards contract for the construction of a 5 story, theatre and apartment building with refrigerating plant, heating system, etc., at Genesse and Clayton Aves., for Burnett, Webb & McDonald. Estimated cost $1,500,000.

Ill., Wilmette—J. Stuart Blackton, c/o Thielbar & Fugard, 219 East Superior St., Archts., is having plans prepared for the construction of club on Lake Shore Dr. Estimated cost $1,500,000.

Mass., Beverly—Beverly Gas & Electric Co., 223 Cabot St., awarded contract for the construction of 1 and 2 story, water gas building extension on Cabot St., to P. J. MacNaughton Co., 755 Boylston St., Boston. Estimated cost $40,000.

Mass., East Cambridge—A. R. Hyde & Sons Co., 432 Columbia St., is in the market for an electric power hammer.

Mass., Springfield—United Electric Co., Springfield, awarded contract for the design and construction of switch house, with equipment, etc., to Stone & Webster, 120 Bway., New York City. Estimated cost $900,000.

Mich., Detroit — J. J. Barlum, Barlum Bldg., will soon receive bids for the construction of 35 story, office building, with steam heating equipment, on Cadillac Sq. Bonnah & Chaffee, Barlum Bldg. are architects.

Mich., Detroit—Eaton Estate, B. Eaton, 204 Woodward Ave., is having plans prepared for the construction of 34 story office building on Woodward Ave. Estimated cost $1,500,000. L. Kamper, Kamper Bldg., Cass Ave., is architect.

Mich., Detroit—Fort Shelby Hotel Co., Lafayette and 1st Sts., is having plans prepared for the construction of 21 story hotel addition, with complete laundry, Lafayette Blvd. $2,000,000. A. Kahn, 1000 Marquette Bldg., is architect.

Mich., Detroit — Stormfeltz-Lovely Co., Washington Blvd. Bldg., is receiving bids for the construction of 8 story office building at Woodward Ave. and East Grand Blvd. Estimated cost $500,000. A. Kahn, 1000 Marquette Bldg., is architect.

Miss., Natchez—City voted $40,000 bonds for extending and improving water works system, including electrical equipment, etc.

Mo., Kansas City—D. A. Schulte Cigars, Inc., c/o A. Schoenberg, Security Bldg., plans the construction of a 16 story office building at 10th and Main Sts., here. Estimated cost $1,100,000. Architect and engineer not selected.

Mo., St. Louis—Central Properties Corp., 706 North Grand St. is receiving bids for the construction of 3 story, apartment, theatre and office building at Easton and Hamilton Aves. Estimated cost $1,000,000. V. W. and G. L. Rapp, 100 State Lake Bldg., Chicago, Ill. are engineers.

Mo., St. Louis—Local Syndicate, c/o H. R. Weisels, 730 Chestnut St., will soon receive bids for the construction of an 18 story office building at Olive and 13th Sts. Estimated cost $1,000,000. P. J. Bradshaw, International Life Bldg., is architect.

N. Y., Buffalo—Switchmen's Union of America, 39 North St., is having plans prepared for the construction of 5 story apartment and office building at North St. and Linwood Ave. Estimated cost $600,000. Bley & Lyman, 505 Delaware Ave., are architects.

N. Y., New York—American Bookbinding Co., 406 West 31st St., will soon receive bids for the construction of 12 story loft building at West Houston, King and Varick Sts. Estimated cost $1,500,000. Parker & Schaffer, 280 Madison Ave., are architects and engineers.

N. Y., New York—A. Brisbane, 238 Williams St., is having plans prepared for the construction of an office building on Madison Ave. Estimated cost $1,650,000. Rouse & Goldstone, 512 5th Ave., are engineers and architects.

N. Y., New York — C. G. Edwards, c/o Jardine, Hill & Murdock, 347 Madison Ave., Engrs. and Archts., is having plans prepared for the construction of 17 story, loft and office building, on Worth St. Estimated cost $6,000,000.

N. Y., New York—J. L. Goldberger, c/o Schwartz & Gross, 347 5th Ave., Archts. and Engrs., is having plans prepared 10 story apartment, on East 81st St. Estimated cost $750,000.

N. Y., New York — N. C. Partos, 283 Madison Ave., will build 12 story office building at 132 West 43rd St. Estimated cost $800,000. Work will be done by day labor.

N. Y., New York—Three Hundred and Fifty Nine West 42nd St. Co. is having plans prepared for the construction of 20 story hotel, on West 42nd St. Estimated cost $1,000,000. Deutsch & Schneider, 35 Maiden Lane, are architects and engineers.

N. C., Elizabeth City—Utility Commission, Chamber of Commerce Bldg., will receive bids until August 17, for construction of waterworks system, including pumping station, equipped with motor driven and gasoline engine centrifugal pumping units, switches, etc. W. C. Olsen, Raleigh is consulting engineer.

N. C., Spencer—Southern Power Co., 432 South Church St., Charlotte, W. S. Lee, engr. has received permission to construct a plant for power and lighting purposes here.

O., Fairport Harbor (Plainsville P. O.) —P. C. Tomson & Co., 27 Washington St., Phila., Pa. awarded contact for the construction of 2 story, factory and boiler house, here to Mitzel-Shields, B. F. Keith Bldg., Cleveland. Estimated cost $150,000.

O., Massillon — Agathon Hotel Co. awarded contract for the construction of 10 story hotel, on Mill and Plum Sts., to Wendling Constr. Co., $1,000,000.

O., Painesville—Lake Erie College for Women awarded contract for the construction of 1 and 2 story boiler house and laundry, to R. M. Higley, Plymouth Bldg., Cleveland. Estimated cost $40,000.

Okla., Anadarko—City is having preliminary plans prepared for an electric distribution system, with 200 hp. turbo generator, ettc. Estimated cost $37,000. H. E. Musson, Oklahoma City, is engineer.

Okla., Poteau—City plans an election to vote $60,000 bonds for electric power plant. A. C. Moore, 221 West 3rd St., Joplin, Mo. is engineer.

Okla., Talgo—City is in the market for deep well pump, etc. for waterworks system. Estimated cost $22,000. N. S. Sherman, 18 East Main St., Oklahoma City is engineer.

Pa., Pittsburgh—J. I. Simon, 527 5th Ave. will soon receive bids for the construction 12 story, office building at 5th Ave. and 6th St. Jardine, Hill and Murdock, 347 Madison Ave., New York City are architects.

Tenn., Chattanooga — Southern Railway, 1300 Penn. Ave., Wash., D. C., awarded contract for the design and construction of locomotive terminal, including power house, etc. to Dwight P. Robinson & Co., 125 East 46th St., New York City.

Tex., Amarillo — Southwestern Public Service Co. is having preliminary plans prepared for the construction of a new power plant, probably located at White Deer. Estimated cost $150,000. Private plans.

Tex., Marlin—City, c/o L. Goodrich, supt. waterworks, is having preliminary plans prepared for the construction of extensions to waterworks, including pumps, etc.

Tex., San Angelo—Marland Oil Co. plans the construction of a steam pump station, in Section 6, Block 35, in Upton Co. New equipment will be installed. Estimated cost $100,000. Private plans.

Wis., Marshfield—Wisconsin Cheese Producers Federation, Plymouth, awarded contract for the construction 2 story cold storage plant to F. A. Felhofer, 700 East 4th St., Marshfield. Estimated cost $60,000. Owner is in the market for refrigerating machinery.

Wis., Milwaukee—F. A. Schaetzke, 1385 Lake Dr., is receiving bids for the construction of superstructures 8 story apartment, hotel and stores building, on Grand Ave. Estimated cost $500,000. C. J. Keller & Sons, 432 Bway. are architects.

Ont., Toronto—City Council is having plans prepared for the construction activated sludge North Toronto Sewage Disposal Plant, with electric centrifugal pumps, etc. in Don Valley, between Leaside and Todmorden. Estimated cost $1,000,000. R. C. Harris, is city engineer. H. P. Eddy, 14 Beacon St., Boston, Mass. and G. G. Nasmith, Confederation Life Bldg. are consulting engineers.

Ont., Toronto — Four Hundred Avenue Road Apartment, c/o Craig & Madill, 96 Bloor St., W., Archts., is having plans prepared for the construction of 4 story apartment, Avenue Rd. Estimated cost $500,000.

Ont., Toronto—Toronto General Hospital, College St., is having plans prepared for the construction of 3 or 5 story hospital group, incl. refrigerating plant, etc., on Elizabeth St. Estimated cost $1,000,000.

Ont., Toronto—Womens College Hospital, 125 Rusholme Rd., is having plans prepared for the construction of 3 or 4 story hospital, with electrically operated refrigeration plant, elevators, etc., Rusholme Rd. Estimated cost $500,000. Stevens & Lee, 62 Charles St., are architects.

B. C., Stave Falls — British Columbia Electric Ry. Co., 425 Carroll St., Vancouver, awarded contract for the construction of 12,500 hp. power house to Northern Constr. Co., Ltd., 736 Granville St., Vancouver, $500,000.

Australia, Melbourne — Secretary Victorian Government Railways will receive bids until September 1, direct current neutral relays for power signaling.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

There is considerably more firmness evident at this time than a month ago in power-plant supplies made from non-ferrous metals. Linseed oil is again on the up-trend in the principal centers. Easing-off is noted in prices of wiping material, steel rivets, boiler flanges, and No. 14 rubber-covered copper wire. Hose, belting, lacing, pipe and boiler covering hold steadily to the July levels.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, single jacket	(net) 74c. per ft.	
Common, 2½-in., cotton-rubber lined	80c. per ft. list less	40%

Air—Best grade

¾-in., per ft.	3-ply	$0.37½	4 ply	$0.46

Steam—Discounts from List

First grade	30-10%	Second grade	40%	Third grade	40-10%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade	50%	Second grade	50-10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40-5%
Heavy	30-10%

RAWHIDE LACING—For cut, best grade, 50%, 2nd grade, 60%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 50%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$1.05
Asbestos for high-pressure steam, ⅛ in.	1.85
Duck and rubber for piston packing	1.05
Flax, regular	1.15
Flax, waterproofed	1.70
Compressed asbestos sheet	.95
Wire insertion asbestos sheet	1.40
Rubber sheet	.60
Rubber sheet, wire insertion	.85
Rubber sheet, duck insertion	.65
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@$2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	13.00@17.50	18.00	15.00
Colored	10.00@14.00	14.00	12.00@17.00

WIPING CLOTHS—Prices per pound in lots of about 600 lb., for washed, white wipers, as follows:

Chicago	$0.15
New York	.17½
Cleveland (*per thousand*)	36.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.94½	$1.05	$0.94

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b. New York:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	$15.25	$15.75	$16.75	$17.25
White	15.25	15.75	15.25	15.75

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

Rivets, ⅞x1-in. and longer, 19c. per lb., less 50% at New York warehouses. Same discount for tinned. EXTRA per 100 lb. for 1¼ to 2-in. long, all diameters, 25c.; ⅞-in. dia., 35c.; ½-in., dia., 75c.; 1-in. long and shorter, 75c.; longer than 5-in., 50c.; less than 200 lb., 50c.; countersunk heads, 45c.

Structural rivets, per 100 lb.:

New York	$4.20	Chicago	$3.50	Pittsburgh	$2.50@2.60

Cone-head boiler rivets, per 100 lb.:

New York	$4.40	Chicago	$3.70	Pittsburgh	$2.90

REFRACTORIES—Prices in car lots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$48@53
Chrome cement, 40@ 50% Cr_2O_3 in bulk	net ton	23@28
Chrome cement, 40@ 50% Cr_2O_3 in sacks	net ton	27@32
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Mt. Union, Pa.	per M	38@40
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	40@47
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	43@45
Clay brick, 1st quality, 9 in. shapes, Maryland	per M	48@50
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	33@40
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	40@43
Clay brick, 2nd quality 9 in. shapes, Maryland	per M	43@45
Chrome ore crude, 40@ 50%	net ton	19.00@20.50

BABBITT METAL—Delivered, New York, cents per lb.:

Genuine, highest grade	79.00
Commercial genuine, intermediate grade	55.00
Anti-friction metal, general service	30.50
No. 4 babbitt (f.o.b.)	14.50

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.00	$3.90	$3.60
Flats and squares, per 100 lb. base	4.50	4.40	4.10

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	65-5%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Galv.	Inches	Iron Black	Galv.
1 to 3	62	50½	1 to 1½	30	12

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1			$17 07
1¼			19 20
1½		$38.00	17 92
1¾		28 50	20 48
2	$17.33	25 00	20 24
2¼	19 84	28 25	23 00
2½	21 60	34 00	26 03
3	25.50	42 50	27 04
3¼	30.25	49 50	30 67
3½	31.50	52 75	33 33
4	38.03	67 00	40.11

Tubes 2¼ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.
These prices are net per 100 ft. based on stock lengths. If cut to special engths, billing will be based on the entire stock lengths.
In addition to the above, standard cutting charges are as follows:
2 in. and smaller, 5c. per cut. 3 in., 9c. per cut
2¼ and 2½ in., 6c. per cut. 3¼ to 4 in., 10c. per cut

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$33.50 (net)	$ 51.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	

From the above lists discounts are:		Lead Covered
Less than coil lots	50%	20%
Coils to 1,000 ft	60%	30%
1,000 to 5,000 ft	60–5%	35%
5,000 ft. and over	60–10%	38%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$56.50	$61.34	$7.76	$8.83	$4.52	$4.92
⅜	72.07	78.63	10.21	11.63	6.46	7.03
½	103.31	113.00	15.10	17.21	8.39	9.13
¾	139.77	152.88	20.51	23.07	11.78	12.75
1	167.12	182.79	27.34	30.76	14.56	15.75
1¼	224.85	245.94	50 13	56.40	19.41	21.01
1½	355.50	388.85	82 03	92 28	27.73	30.01
2	464.88	508.50	218.74	246 10	41.59	45.01
2½	585.30	637.74	483.04	543.46	55.46	60.02
3	714 17	776.30	558.23	628.06	69.32	75.02

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG, SOLID NEUTRAL OR 2 FUSE

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE, SOLID NEUTRAL OR 2 FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	
T. P. S. B.	.67	1.50	
D. P. D. B.	.65	1.75	
T. P. D. B.	1.12	3.00	
T. P. to D. P. D. B.	.75	2.10	

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy		$19.25
No. 16 cotton reinforced heavy		23.50
No. 18 cotton reinforced light		16.00
No. 16 cotton reinforced light		20.50
No. 18 cotton Canvasite cord		15.50
No. 16 cotton Canvasite cord		19.00
No. 16 super service cord or similar (2 wire) in 1,000 ft	$92.00	*101.20
No. 14 super service cord or similar (2 wire) in 1,000 ft	133.00	*146 40

*Less than 1,000 ft.

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.15	3-amp. to 30-amp.,	100	$0.30
35-amp. to 60-amp.,	100	.30	35-amp. to 60-amp.,	100	.60
61-amp. to 100-amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
101-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
201-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
401-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 60%; 1-5th to standard package, 64%; standard package, 68%.

RENEWABLE FUSES—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4 00	5.00	25	5
225 to 400-amp.	7.50	11 00	25	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30-amp.	$0.03 ea.	$0.05	100	100
35 to 60-amp.	.05 ea.	.06	100	100
65 to 100-amp.	.10 ea.	.10	50	50
110 to 200-amp.	.15 ea.	.15	25	50
225 to 400-amp.	.30 ea.	.30	25	25
450 to 600-amp.	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package (500)	$2.75
0–30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities on Mazda standard A type bulbs:

100—130 Volt Watts	Type	Price Each	200—260 Volt Watts	Type	Price Each
Decorative			Special		
15	A 17	$0.27	25	A 19	$0.32
General			50	A 21	.32
25	A 19	.27	100	A 23	.55
40	A 21	.27			
50	A 21	.29			
60	A 21	.32			
100	A 23	.45			

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Small size—2 Pc. Plug—Composition	.07

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$6.55	$9.75	$11.60	$18.20
12	10.10	12.60	14.60	23.80
10	13.20	16.40	18.60	30.50
8	19.00	22.30	24.20	42.40
6			34.40	
4			48 00	
2			68.75	
1			94.70	
0			115 00	
00			138 00	
000			165 00	
0000			196 00	

SOCKETS, BRASS SHELL—Price each, net:

	½ In. or Pendant Cap Key	Keyless	Pull	⅜ In. Cap Key	Keyless	Pull
Standard package.	$0.17	$0.15	$0.22	$0.20	$0.18	$0.25
Unbroken carton..	.18	.16	.23	.22	.19	.26
Broken carton....	.20	.18	.25	.24	.21	.28

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 35c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 37c. lb., 100 lb. lots	35c. lb.
Wire solder, less 100 lb. 29c. lb., 100 lb. lots	31c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25.00 to $50.00 list value	30–5%
$50.00 list value or over	35%